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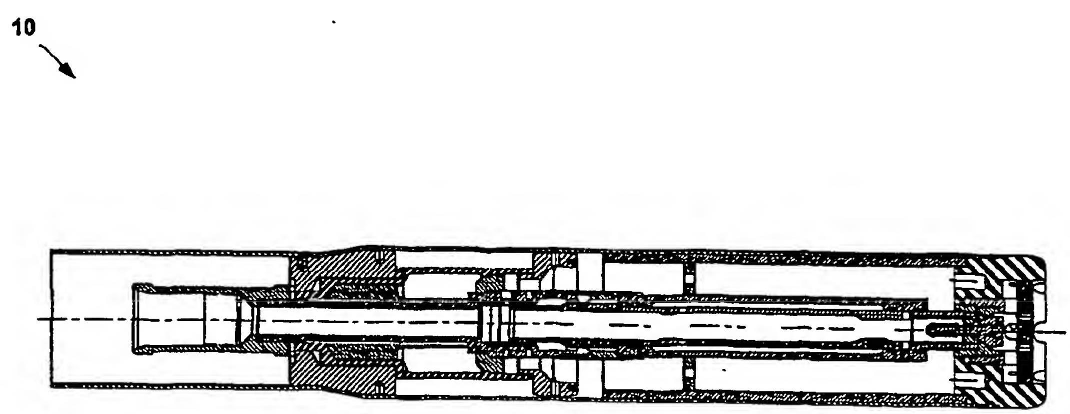
(54) Title: LINER HANGER WITH SLIDING SLEEVE VALVE



(57) Abstract: An apparatus and method for forming or repairing a wellbore casing, a pipeline, or a structural support is disclosed. An expandab le tubular member (20a) is radially expanded and plastically deformed by an expansion cone (18) that is displaced by hydraulic pressure. Before or after the radial expansion of the expandable tubular member (20a), sliding sleeve valve (42) within the apparatus permit a hardenable fluidic sealing material to be injected into an annulus between the expandable tubular member (20a) and a preexisting structure.

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LINER HANGER WITH SLIDING SLEEVE VALVE

Cross Reference To Related Applications

This application claims the benefit of the filing date of U.S. provisional patent application serial number 60/233,638, attorney docket number 25791.47, filed on 9/18/2000, the disclosure of which is incorporated herein by reference.

This application is related to the following co-pending applications: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) U.S. patent application serial no. ___________, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. _____________, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. ___________, attorney docket no. 25791.45, filed on 7/28/2000, and (19) U.S. provisional patent application serial no. ___________, attorney docket no.

25791.46, filed on 7/28/2000. Applicants incorporate by reference the disclosures of these applications.

Background of the Invention

This invention relates generally to wellbore casings, and in particular to wellbore casings that are formed using expandable tubing.

Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores.

Summary of the Invention

According to one aspect of the invention, a method of forming a wellbore casing within a borehole within a subterranean formation is provided that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, fluidicly coupling the first and second regions, injecting a hardenable

fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, a method of forming a wellbore casing within a borehole within a subterranean formation is provided that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second

region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

According to another aspect of the present invention, an apparatus for forming a wellbore casing in a borehole in a subterranean formation is provided that includes means for radially expanding an expandable tubular member and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

According to another aspect of the present invention, a method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided. The apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

According to another aspect of the present invention, a method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided in which the apparatus includes a first annular support member defining a first fluid passage and one or more first

radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

According to one aspect of the invention, a method of coupling an expandable tubular member to a preexisting structure is provided that includes positioning an expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular

member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, a method of coupling an expandable tubular member to a preexisting structure is provided that includes positioning the expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable

tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for radially expanding an expandable tubular member and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

According to another aspect of the present invention, a method of operating an apparatus for coupling an expandable tubular member to a preexisting structure is provided. The apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

According to another aspect of the present invention, a method of operating an apparatus for coupling an expandable tubular member to a preexisting structure is provided in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial

passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

Brief Description of the Drawings

Figs. 1 and 1a-1c are cross sectional illustrations of an embodiment of a liner hanger assembly including a sliding sleeve valve assembly.

Figs. 2a-2b is a flow chart illustration of an embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 1 and 1a-1c.

Figs. 3a-3c are cross sectional illustrations of the placement of the liner hanger assembly of Figs. 1 and 1a-1c into a wellbore.

Figs. 4a-4c are cross sectional illustrations of the injection of a fluidic materials into the liner hanger assembly of Figs. 3a-3c.

Figs. 5a-5c are cross sectional illustrations of the placement of a bottom plug into the liner hanger assembly of Figs. 4a-4c.

Figs. 6a-6c are cross sectional illustrations of the downward displacement of sliding sleeve of the liner hanger assembly of Figs. 5a-5c.

Figs. 7a-7c are cross sectional illustrations of the injection of a hardenable fluidic sealing material into the liner hanger assembly of Figs. 6a-6c that bypasses the plug.

Figs. 8a-8c are cross sectional illustrations of the placement of a top plug into the liner hanger assembly of Figs. 7a-7c.

Figs. 9a-9c are cross sectional illustrations of the upward displacement of sliding sleeve of the liner hanger assembly of Figs. 8a-8c.

Figs. 10a-10c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 9a-9c in order to radially expand and plastically deform the expansion cone launcher.

Figs. 11a-11b is a flow chart illustration of an alternative embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 1 and 1a-1c.

Figs. 12a-12c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 5a-5c in order to at least partially radially expand and plastically deform the expansion cone launcher.

Figs. 13a-13c are cross sectional illustrations of the downward displacement of the sliding sleeve of the liner hanger assembly of Figs. 12a-12c.

Figs. 14a-14c are cross sectional illustrations of the injection of a hardenable fluidic sealing material through the liner hanger assembly of Figs. 13a-13c.

Figs. 15a-15c are cross sectional illustrations of the injection and placement of a top plug into the liner hanger assembly of Figs. 14a-14c.

Figs. 16a-16c are cross sectional illustrations of the upward displacement of the sliding sleeve of the liner hanger assembly of Figs. 15a-15c.

Figs. 17a-17c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 16a-16c in order to complete the radial expansion of the expansion cone launcher.

Figs. 18, 18a, 18b, and 18c are cross sectional illustrations of an alternative embodiment of a liner hanger assembly including a sliding sleeve valve assembly.

Figs. 19a-19b is a flow chart illustration of an embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 18 and 18a-18c.

Figs. 20a-20c are cross sectional illustrations of the placement of the liner hanger assembly of Figs. 18 and 18a-18c into a wellbore.

Figs. 21a-21c are cross sectional illustrations of the injection of a fluidic materials into the liner hanger assembly of Figs. 20a-20c.

Figs. 22a-22c are cross sectional illustrations of the placement of a bottom plug into the liner hanger assembly of Figs. 21a-21c.

Figs. 23a-23c are cross sectional illustrations of the downward displacement of sliding sleeve of the liner hanger assembly of Figs. 22a-22c.

Figs. 24a-24c are cross sectional illustrations of the injection of a hardenable fluidic sealing material into the liner hanger assembly of Figs. 23a-23c that bypasses the bottom plug.

Figs. 25a-25c are cross sectional illustrations of the placement of a top plug into the liner hanger assembly of Figs. 24a-24c.

Figs. 26a-26c are cross sectional illustrations of the upward displacement of sliding sleeve of the liner hanger assembly of Figs. 25a-25c.

Figs. 27a-27c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 26a-26c in order to radially expand and plastically deform the expansion cone launcher.

Figs. 28a-28b is a flow chart illustration of an alternative embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 18 and 18a-18c.

Figs. 29a-29c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 22a-22c in order to at least partially radially expand and plastically deform the expansion cone launcher.

Figs. 30a-30c are cross sectional illustrations of the downward displacement of the sliding sleeve of the liner hanger assembly of Figs. 29a-29c.

Figs. 31a-31c are cross sectional illustrations of the injection of a hardenable fluidic sealing material through the liner hanger assembly of Figs. 30a-30c.

Figs. 32a-32c are cross sectional illustrations of the injection and placement of a top plug into the liner hanger assembly of Figs. 31a-31c.

Figs. 33a-33c are cross sectional illustrations of the upward displacement of the sliding sleeve of the liner hanger assembly of Figs. 32a-32c.

Figs. 34a-34c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 33a-33c in order to complete the radial expansion of the expansion cone launcher.

Detailed Description

A liner hanger assembly having sliding sleeve bypass valve is provided. In several alternative embodiments, the liner hanger assembly provides a method and apparatus for forming or repairing a wellbore casing, a pipeline or a structural support.

Referring initially to Figs. 1, 1a, 1b, and 1c, an embodiment of a liner hanger assembly 10 includes a first tubular support member 12 defining an internal passage 12a that includes a threaded counterbore 12b at one end, and a threaded counterbore 12c at another end. A second tubular support member 14 defining an internal passage 14a includes a first threaded portion 14b at a first end that is coupled to the threaded counterbore 12c of the first tubular support member 12, a stepped flange 14c, a counterbore 14d, a threaded portion 14e, and internal splines 14f at another end. The stepped flange 14c of the second tubular support member 14 further defines radial passages 14g, 14h, 14i, and 14j. A third tubular support member 16 defining an internal passage 16a for receiving the second tubular support member 14 includes a first flange 16b, a

second flange 16c, a first counterbore 16d, a second counterbore 16e having an internally threaded portion 16f, and an internal flange 16g. The second flange 16c further includes radial passages 16h and 16i.

An annular expansion cone 18 defining an internal passage 18a for receiving the second and third tubular support members, 14 and 16, includes a counterbore 18b at one end, and a counterbore 18c at another end for receiving the flange 16b of the second tubular support member 16. The annular expansion cone 18 further includes an end face 18d that mates with an end face 16j of the flange 16c of the second tubular support member 16, and an exterior surface 18e having a conical shape in order to facilitate the radial expansion of tubular members. A tubular expansion cone launcher 20 is movably coupled to the exterior surface 18e of the expansion cone 18 and includes a first portion 20a having a first wall thickness, a second portion 20b having a second wall thickness, a threaded portion 20c at one end, and a threaded portion 20d at another end. In a preferred embodiment, the second portion 20b of the expansion cone launcher 20 mates with the conical outer surface 18e of the expansion cone 18. In a preferred embodiment, the second wall thickness is less than the first wall thickness in order to optimize the radial expansion of the expansion cone launcher 20 by the relative axial displacement of the expansion cone 18. In a preferred embodiment, one or more expandable tubulars are coupled to the threaded connection 20c of the expansion cone launcher 20. In this manner, the assembly 10 may be used to radially expand and plastically deform, for example, thousands of feet of expandable tubulars.

An annular spacer 22 defining an internal passage 22a for receiving the second tubular support member 14 is received within the counterbore 18b of the expansion cone 18, and is positioned between an end face 12d of the first tubular support member 12 and an end face of the counterbore 18b of the expansion cone 18. A fourth tubular support member 24 defining an internal passage 24a for receiving the second tubular support member 14 includes a flange 24b that is received within the counterbore 16d of the third tubular support member 16. A fifth tubular support member 26 defining an internal passage 26a for receiving the second tubular support member 14 includes an

internal flange 26b for mating with the flange 14c of the second tubular support member and a flange 26c for mating with the internal flange 16g of the third tubular support member 16.

An annular sealing member 28, an annular sealing and support member 30, an annular sealing member 32, and an annular sealing and support member 34 are received within the counterbore 14d of the second tubular support member 14. The annular sealing and support member 30 further includes a radial opening 30a for supporting a rupture disc 36 within the radial opening 14g of the second tubular support member 14 and a sealing member 30b for sealing the radial opening 14h of the second tubular support member. The annular sealing and support member 34 further includes sealing members 34a and 34b for sealing the radial openings 14i and 14j, respectively, of the second tubular support member 14. In an exemplary embodiment, the rupture disc 36 opens when the operating pressure within the radial opening 30b is about 1000 to 5000 psi. In this manner, the rupture disc 36 provides a pressure sensitive valve for controlling the flow of fluidic materials through the radial opening 30a. In several alternative embodiments, the assembly 10 includes a plurality of radial passages 30a, each with corresponding rupture discs 36.

A sixth tubular support member 38 defining an internal passage 38a for receiving the second tubular support member 14 includes a threaded portion 38b at one end that is coupled to the threaded portion 16f of the third tubular support member 16 and a flange 38c at another end that is movably coupled to the interior of the expansion cone launcher 20. An annular collet 40 includes a threaded portion 40a that is coupled to the threaded portion 14e of the second tubular support member 14, and a resilient coupling 40b at another end.

An annular sliding sleeve 42 defining an internal passage 42a includes an internal flange 42b, having sealing members 42c and 42d, and an external groove 42e for releasably engaging the coupling 40b of the collet 40 at one end, and an internal flange 42f, having sealing members 42g and 42h, at another end. During operation the coupling 40b of the collet 40 may engage the external groove 42e of the sliding sleeve 42 and thereby displace the sliding sleeve in the longitudinal direction. Since the coupling 40b of the collet 40 is

resilient, the collet 40 may be disengaged or reengaged with the sliding sleeve 42. An annular valve member 44 defining an internal passage 44a, having a first throat 44aa and a second throat 44ab, includes a flange 44b at one end, having external splines 44c for engaging the internal splines 14f of the second tubular support member 14, a first set of radial passages, 44da and 44db, a second set of radial passages, 44ea and 44eb, and a threaded portion 44f at another end. The sliding sleeve 42 and the valve member 44 define an annular bypass passage 46 that, depending upon the position of the sliding sleeve 42, permits fluidic materials to flow from the passage 44 through the first radial passages, 44da and 44db, the bypass passage 46, and the second radial passages, 44ea and 44eb, back into the passage 44. In this manner, fluidic materials may bypass the portion of the passage 44 between the first and second radial passages, 44ea, 44eb, 44da, and 44db. Furthermore, the sliding sleeve 42 and the valve member 44 together define a sliding sleeve valve for controllably permitting fluidic materials to bypass the intermediate portion of the passage 44a between the first and second passages, 44da, 44db, 44ea, and 44eb. During operation, the flange 44b limits movement of the sliding sleeve 42 in the longitudinal direction.

In a preferred embodiment, the collet 40 includes a set of couplings 40b such as, for example, fingers, that engage the external groove 42e of the sliding sleeve 42. During operation, the collet couplings 40b latch over and onto the external groove 42e of the sliding sleeve 42. In a preferred embodiment, a longitudinal force of at least about 10,000 to 13,000 lbf is required to pull the couplings 40b off of, and out of engagement with, the external groove 42e of the sliding sleeve 42. In an exemplary embodiment, the application of a longitudinal force less than about 10,000 to 13,000 lbf indicates that the collet couplings 40b are latched onto the external shoulder of the sliding sleeve 42, and that the sliding sleeve 42 is in the up or the down position relative to the valve member 44. In a preferred embodiment, the collet 40 includes a conventional internal shoulder that transfers the weight of the first tubular support member 12 and expansion cone 18 onto the sliding sleeve 42. In a

preferred embodiment, the collet 40 further includes a conventional set of internal lugs for engaging the splines 44c of the valve member 44.

An annular valve seat 48 defining a conical internal passage 48a for receiving a conventional float valve element 50 includes an annular recess 48b, having an internally threaded portion 48c for engaging the threaded portion 44f of the valve member 44, at one end, and an externally threaded portion 48d at another end. In an alternative embodiment, the float valve element 50 is omitted. An annular valve seat mounting element 52 defining an internal passage 52a for receiving the valve seat 48 and float valve 50 includes an internally threaded portion 52b for engaging the externally threaded portion 48d of the valve seat 48, an externally threaded portion 52c, an internal flange 52d, radial passages, 52ea and 52eb, and an end member 52f, having axial passages, 52fa and 52fb.

A shoe 54 defining an internal passage 54a for receiving the valve seat mounting element 52 includes a first annular recess 54b, having an externally threaded portion 54c, and a second annular recess 54d, having an externally threaded portion 54e for engaging the threaded portion 20d of the expansion cone launcher 20, at one end, a first threaded counterbore 54f for engaging the threaded portion 52c of the of the mounting element, and a second counterbore 54g for mating with the end member 52f of the mounting element. In a preferred embodiment, the shoe 54 is fabricated from a ceramic and/or a composite material in order to facilitate the subsequent removal of the shoe by drilling. A seventh tubular support member 56 defining an internal passage 56a for receiving the sliding sleeve 42 and the valve member 44 is positioned within the expansion cone launcher 20 that includes an internally threaded portion 56b at one end for engaging the externally threaded portion 54c of the annular recess 54b of the shoe 54. In a preferred embodiment, during operation of the assembly, the end of the seventh tubular support member 56 limits the longitudinal movement of the expansion cone 18 in the direction of the shoe 54 by limiting the longitudinal movement of the sixth tubular support member 38. An annular centralizer 58 defining an internal passage 58a for movably supporting the sliding sleeve 42 is positioned within the seventh tubular

support member 56 that includes axial passages 58b and 58c. In a preferred embodiment, the centralizer 58 maintains the sliding sleeve 42 and valve member 44 is a central position within the assembly 10.

Referring to Figs. 2a-2b, during operation, the assembly 10 may be used to form or repair a wellbore casing by implementing a method 200 in which, as illustrated in Figs. 3a-3c, the assembly 10 may initially be positioned within a wellbore 100 having a preexisting wellbore casing 102 by coupling a conventional tubular member 104 defining an internal passage 104a to the threaded portion 12b of the first tubular support member 12 in step 202. In a preferred embodiment, during placement of the assembly 10 within the wellbore 100, fluidic materials 106 within the wellbore 100 below the assembly 10 are conveyed through the assembly 10 and into the passage 104a by the fluid passages 52fa, 52fb, 54a, 48a, 44a, and 14a. In this manner, surge pressures that can be created during placement of the assembly 10 within the wellbore 100 are minimized. In a preferred embodiment, the float valve element 50 is pre-set in an auto-fill configuration to permit the fluidic materials 106 to pass through the conical passage 48a of the valve seat 48.

Referring to Figs. 4a-4c, in step 204, fluidic materials 108 may then be injected into and through the tubular member 104 and assembly 10 to thereby ensure that all of the fluid passages 104a, 14a, 44a, 48a, 54a, 52fa, and 52fb are functioning properly.

Referring to Figs. 5a-5c, in step 206, a bottom plug 110 may then be injected into the fluidic materials 108 and into the assembly 10 and then positioned in the throat passage 44ab of the valve member 44. In this manner, the region of the passage 44a upstream from the plug 110 may be fluidicly isolated from the region of the passage 44a downstream from the plug 110. In a preferred embodiment, the proper placement of the plug 110 may be indicated by a corresponding increase in the operating pressure of the fluidic material 108.

Referring to Figs. 6a-6c, in step 208, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104 by applying, for example, a downward force of approximately 5,000 lbf on the

assembly 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the rupture disc 36 is fluidicly isolated from the passages 14a and 44a.

Referring to Figs. 7a-7c, in step 210, a hardenable fluidic sealing material 112 may then be injected into the assembly 10 and conveyed through the passages 104a, 14a, 44a, 44da, 44db, 46, 44ea, 44eb, 48a, 54a, 52fa, and 52fb into the wellbore 100. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 20 and the wellbore 100 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 20. Furthermore, in this manner, the radial passage 30a and the rupture disc 36 are not exposed to the hardenable fluidic sealing material 112.

Referring to Figs. 8a-8c, in step 212, upon the completion of the injection of the hardenable fluidic sealing material 112, a nonhardenable fluidic material 114 may be injected into the assembly 10, and a top plug 116 may then be injected into the assembly 10 along with the fluidic materials 114 and then positioned in the throat passage 44aa of the valve member 44. In this manner, the region of the passage 44a upstream from the first passages, 44da and 44db, may be fluidicly isolated from the first passages. In a preferred embodiment, the proper placement of the plug 116 may be indicated by a corresponding increase in the operating pressure of the fluidic material 114.

Referring to Fig. 9a-9c, in step 214, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104

by applying, for example, an upward force of approximately 13,000 lbf on the assembly 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may no longer bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the rupture disc 36 is no longer fluidicly isolated from the fluid passages 14a and 44a.

Referring to Figs. 10a-10c, in step 216, the fluidic material 114 may be injected into the assembly 10. The continued injection of the fluidic material 114 may increase the operating pressure within the passages 14a and 44a until the burst disc 36 is opened thereby permitting the pressurized fluidic material 114 to pass through the radial passage 30a and into an annular region 118 defined by the second tubular support member 14, the third tubular support member 16, the sixth tubular support member 38, the collet 40, the sliding sleeve 42, the shoe 54, and the seventh tubular support member 56. The pressurized fluidic material 114 within the annular region 118 directly applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby radially expanding and plastically deforming the expansion cone launcher.

In an alternative embodiment of the method 200, the injection and placement of the top plug 116 into the liner hanger assembly 10 in step 212 may omitted.

In an alternative embodiment of the method 200, in step 202, the assembly 10 is positioned at the bottom of the wellbore 100.

In an alternative embodiment, as illustrated in Figs. 11a-11b, during operation, the assembly 10 may be used to form or repair a wellbore casing by implementing a method 250 in which, as illustrated in Figs. 3a-3c, the assembly 10 may initially be positioned within a wellbore 100 having a preexisting wellbore casing 102 by coupling a conventional tubular member 104 defining an internal passage 104a to the threaded portion 12b of the first tubular support member 12 in step 252. In a preferred embodiment, during placement of the assembly 10 within the wellbore 100, fluidic materials 106 within the wellbore 100 below the assembly 10 are conveyed through the assembly 10 and into the passage 104a by the fluid passages 52fa, 52fb, 54a, 48a, 44a, and 14a. In this manner, surge pressures that can be created during placement of the assembly 10 within the wellbore 100 are minimized. In a preferred embodiment, the float valve element 50 is pre-set in an auto-fill configuration to permit the fluidic materials 106 to pass through the conical passage 48a of the valve seat 48.

Referring to Figs. 4a-4c, in step 254, fluidic materials 108 may then be injected into and through the tubular member 104 and assembly 10 to thereby ensure that all of the fluid passages 104a, 14a, 44a, 48a, 54a, 52fa, and 52fb are functioning properly.

Referring to Figs. 5a-5c, in step 256, the bottom plug 110 may then be injected into the fluidic materials 108 and into the assembly 10 and then positioned in the throat passage 44ab of the valve member 44. In this manner, the region of the passage 44a upstream from the plug 110 may be fluidicly isolated from the region of the passage 44a downstream from the plug 110. In a preferred embodiment, the proper placement of the plug 110 may be indicated by a corresponding increase in the operating pressure of the fluidic material 108.

Referring to Figs. 12a-12c, in step 258, a fluidic material 114 may then be injected into the assembly to thereby increase the operating pressure within the passages 14a and 44a until the burst disc 36 is opened thereby permitting the pressurized fluidic material 114 to pass through the radial passage 30a and into an annular region 118 defined by the second tubular support member 14, the third tubular support member 16, the sixth tubular support member 38, the

collet 40, the sliding sleeve 42, the shoe 54, and the seventh tubular support member 56. The pressurized fluidic material 114 within the annular region 118 directly applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby disengaging the collet 40 and the sliding sleeve 42 and radially expanding and plastically deforming the expansion cone launcher. In a preferred embodiment, the radial expansion process in step 408 is continued to a location below the overlap between the expansion cone launcher 20 and the preexisting wellbore casing 102.

Referring to Figs. 13a-13c, in step 260, the sliding sleeve 42 may then be displaced relative to the valve member 44 by (1) displacing the expansion cone 18 in a downward direction using the tubular member 104 and (2) applying, using the tubular member 104 a downward force of, for example, approximately 5,000 lbf on the assembly 10. In this manner, the coupling 40b of the collet 40 reengages the external groove 42e of the sliding sleeve 42. Furthermore, in this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the fluid passage 30a is fluidicly isolated from the passages 14a and 44a.

Referring to Figs. 14a-14c, in step 262, the hardenable fluidic sealing material 112 may then be injected into the assembly 10 and conveyed through the passages 104a, 14a, 44a, 44da, 44db, 46, 44ea, 44eb, 48a, 54a, 52fa, and 52fb

into the wellbore 100. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 20 and the wellbore 100 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 20. Furthermore, in this manner, the radial passage 30a and the rupture disc 36 are not exposed to the hardenable fluidic sealing material 112.

Referring to Figs. 15a-15c, in step 264, upon the completion of the injection of the hardenable fluidic sealing material 112, the nonhardenable fluidic material 114 may be injected into the assembly 10, and the top plug 116 may then be injected into the assembly 10 along with the fluidic materials 114 and then positioned in the throat passage 44aa of the valve member 44. In this manner, the region of the passage 44a upstream from the first passages, 44da and 44db, may be fluidicly isolated from the first passages. In a preferred embodiment, the proper placement of the plug 116 may be indicated by a corresponding increase in the operating pressure of the fluidic material 114.

Referring to Figs. 16a-16c, in step 266, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104 by applying, for example, an upward force of approximately 13,000 lbf on the assembly 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may no longer bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the passage 30a is no longer fluidicly isolated from the fluid passages 14a and 44a.

Referring to Figs. 17a-17c, in step 268, the fluidic material 114 may be injected into the assembly 10. The continued injection of the fluidic material

114 may increase the operating pressure within the passages 14a, 30a, and 44a and the annular region 118. The pressurized fluidic material 114 within the annular region 118 directly applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby completing the radial expansion of the expansion cone launcher.

In an alternative embodiment of the method 250, the injection and placement of the top plug 116 into the liner hanger assembly 10 in step 264 may omitted.

In an alternative embodiment of the method 250, in step 252, the assembly 10 is positioned at the bottom of the wellbore 100.

In an alternative embodiment of the method 250: (1) in step 252, the assembly 10 is positioned proximate a position below a preexisting section of the wellbore casing 102, and (2) in step 258, the expansion cone launcher 20, and any expandable tubulars coupled to the threaded portion 20c of the expansion cone launcher, are radially expanded and plastically deformed until the shoe 54 of the assembly 10 is proximate the bottom of the wellbore 100. In this manner, the radial expansion process using the assembly 10 provides a telescoping of the radially expanded tubulars into the wellbore 100.

In several alternative embodiments, the assembly 10 may be operated to form a wellbore casing by including or excluding the float valve 50.

In several alternative embodiments, the float valve 50 may be operated in an auto-fill configuration in which tabs are positioned between the float valve 50 and the valve seat 48. In this manner, fluidic materials within the wellbore 100 may flow into the assembly 10 from below thereby decreasing surge pressures during placement of the assembly 10 within the wellbore 100. Furthermore, pumping fluidic materials through the assembly 10 at rate of about 6 to 8 bbl/min will displace the tabs from the valve seat 48 and thereby allow the float valve 50 to close.

In several alternative embodiments, prior to the placement of any of the plugs, 110 and 116, into the assembly 10, fluidic materials can be circulated through the assembly 10 and into the wellbore 100.

In several alternative embodiments, once the bottom plug 110 has been positioned into the assembly 10, fluidic materials can only be circulated through the assembly 10 and into the wellbore 100 if the sliding sleeve 42 is in the down position.

In several alternative embodiments, once the sliding sleeve 42 is positioned in the down position, the passage 30a and rupture disc 36 are fluidicly isolated from pressurized fluids within the assembly 10.

In several alternative embodiments, once the top plug 116 has been positioned into the assembly 10, no fluidic materials can be circulated through the assembly 10 and into the wellbore 100.

In several alternative embodiments, the assembly 10 may be operated to form or repair a wellbore casing, a pipeline, or a structural support.

Referring to Figs. 18, 18a, 18b, and 18c, an alternative embodiment of a liner hanger assembly 300 includes a first tubular support member 312 defining an internal passage 312a that includes a threaded counterbore 312b at one end, and a threaded counterbore 312c at another end. A second tubular support member 314 defining an internal passage 314a includes a first threaded portion 314b at a first end that is coupled to the threaded counterbore 312c of the first tubular support member 312, a stepped flange 314c, a counterbore 314d, a threaded portion 314e, and internal splines 314f at another end. The stepped flange 314c of the second tubular support member 314 further defines radial passages 314g, 314h, 314i, and 314j.

A third tubular support member 316 defining an internal passage 316a for receiving the second tubular support member 314 includes a first flange 316b, a second flange 316c, a first counterbore 316d, a second counterbore 316e having an internally threaded portion 316f, and an internal flange 316g. The second flange 316c further includes radial passages 316h and 316i.

An annular expansion cone 318 defining an internal passage 318a for receiving the second and third tubular support members, 314 and 316, includes

a counterbore 318b at one end, and a counterbore 318c at another end for receiving the flange 316b of the second tubular support member 316. The annular expansion cone 318 further includes an end face 318d that mates with an end face 316j of the flange 316c of the second tubular support member 316, and an exterior surface 318e having a conical shape in order to facilitate the radial expansion of tubular members. A tubular expansion cone launcher 320 is movably coupled to the exterior surface 318e of the expansion cone 318 and includes a first portion 320a having a first wall thickness, a second portion 320b having a second wall thickness, a threaded portion 320c at one end, and a threaded portion 320d at another end. In a preferred embodiment, the second portion 320b of the expansion cone launcher 320 mates with the conical outer surface 318e of the expansion cone 318. In a preferred embodiment, the second wall thickness of the second portion 320b is less than the first wall thickness of the first portion 320a in order to optimize the radial expansion of the expansion cone launcher 320 by the relative axial displacement of the expansion cone 318. In a preferred embodiment, one or more expandable tubulars are coupled to the threaded connection 320c of the expansion cone launcher 320. In this manner, the assembly 300 may be used to radially expand and plastically deform, for example, thousands of feet of expandable tubulars.

An annular spacer 322 defining an internal passage 322a for receiving the second tubular support member 314 is received within the counterbore 318b of the expansion cone 318, and is positioned between an end face 312d of the first tubular support member 312 and an end face of the counterbore 318b of the expansion cone 318. A fourth tubular support member 324 defining an internal passage 324a for receiving the second tubular support member 314 includes a flange 324b that is received within the counterbore 316d of the third tubular support member 316. A fifth tubular support member 326 defining an internal passage 326a for receiving the second tubular support member 314 includes an internal flange 326b for mating with the flange 314c of the second tubular support member and a flange 326c for mating with the internal flange 316g of the third tubular support member 316.

An annular sealing member 328, an annular sealing and support member 330, an annular sealing member 332, and an annular sealing and support member 334 are received within the counterbore 314d of the second tubular support member 314. The annular sealing and support member 330 further includes a radial opening 330a for supporting a rupture disc 336 within the radial opening 314g of the second tubular support member 314 and a sealing member 330b for sealing the radial opening 314h of the second tubular support member. The annular sealing and support member 334 further includes sealing members 334a and 334b for sealing the radial openings 314i and 314j, respectively, of the second tubular support member 314. In an exemplary embodiment, the rupture disc 336 opens when the operating pressure within the radial opening 330b is about 1000 to 5000 psi. In this manner, the rupture disc 336 provides a pressure sensitive valve for controlling the flow of fluidic materials through the radial opening 330a. In several alternative embodiments, the assembly 300 includes a plurality of radial passages 330a, each with corresponding rupture discs 336.

A sixth tubular support member 338 defining an internal passage 338a for receiving the second tubular support member 314 includes a threaded portion 338b at one end that is coupled to the threaded portion 316f of the third tubular support member 316 and a flange 338c at another end that is movably coupled to the interior of the expansion cone launcher 320. An annular collet 340 includes a threaded portion 340a that is coupled to the threaded portion 314e of the second tubular support member 314, and a resilient coupling 340b at another end.

An annular sliding sleeve 342 defining an internal passage 342a includes an internal flange 342b, having sealing members 342c and 342d, and an external groove 342e for releasably engaging the coupling 340b of the collet 340 at one end, and an internal flange 342f, having sealing members 342g and 342h, at another end. During operation, the coupling 340b of the collet 340 may engage the external groove 342e of the sliding sleeve 342 and thereby displace the sliding sleeve in the longitudinal direction. Since the coupling 340b of the collet 340 is resilient, the collet 340 may be disengaged or reengaged with the

sliding sleeve 342. An annular valve member 344 defining an internal passage 344a, having a throat 344aa, includes a flange 344b at one end, having external splines 344c for engaging the internal splines 314f of the second tubular support member 314, an interior flange 344d having a first set of radial passages, 344da and 344db, and a counterbore 344e, a second set of radial passages, 344fa and 344fb, and a threaded portion 344g at another end.

An annular valve member 346 defining an internal passage 346a, having a throat 346aa, includes an end portion 346b that is received in the counterbore 344e of the annular valve member 344, a set of radial openings, 346ca and 346cb, and a flange 346d at another end. An annular valve member 348 defining an internal passage 348a for receiving the annular valve members 344 and 346 includes a flange 348b having a threaded counterbore 348c at one end for engaging the threaded portion 344g of the annular valve member, a counterbore 348d for mating with the flange 346d of the annular valve member, and a threaded annular recess 348e at another end.

The annular valve members 344, 346, and 348 define an annular passage 350 that fluidicly couples the radial passages 344fa, 344fb, 346ca, and 346cb. Furthermore, depending upon the position of the sliding sleeve 342, the fluid passages, 344da and 344db, may be fluidicly coupled to the passages 344fa, 344fb, 346ca, 346cb, and 350. In this manner, fluidic materials may bypass the portion of the passage 346a between the passages 344da, 344db, 346ca, and 346cb. Furthermore, the sliding sleeve 342 and the valve members 344, 346, and 348 together define a sliding sleeve valve for controllably permitting fluidic materials to bypass the intermediate portion of the passage 346a between the passages, 344da, 344db, 346ca, and 346cb. During operation of the sliding sleeve valve, the flange 348b limits movement of the sliding sleeve 342 in the longitudinal direction.

In a preferred embodiment, the collet 340 includes a set of couplings 340b that engage the external groove 342e of the sliding sleeve 342. During operation, the collet couplings 340b latch over and onto the external groove 342e of the sliding sleeve 342. In a preferred embodiment, a longitudinal force of at least about 10,000 to 13,000 lbf is required to pull the couplings 340b off

of, and out of engagement with, the external groove 342e of the sliding sleeve 342. In an exemplary embodiment, the application of a longitudinal force less than about 10,000 to 13,000 lbf indicates that the collet couplings 340b are latched onto the external shoulder of the sliding sleeve 342, and that the sliding sleeve 342 is in the up or the down position relative to the valve member 344. In a preferred embodiment, the collet 340 includes a conventional internal shoulder that transfers the weight of the first tubular support member 312 and expansion cone 318 onto the sliding sleeve 342. In a preferred embodiment, the collet 340 further includes a conventional set of internal lugs for engaging the splines 344c of the valve member 344.

An annular valve seat 352 defining a conical internal passage 352a for receiving a conventional float valve element 354 includes a threaded annular recess 352b for engaging the threaded portion 348e of the valve member 348, at one end, and an externally threaded portion 352c at another end. In an alternative embodiment, the float valve element 354 is omitted. An annular valve seat mounting element 356 defining an internal passage 356a for receiving the valve seat 352 and float valve 354 includes an internally threaded portion 356b for engaging the externally threaded portion 352c of the valve seat 352, an externally threaded portion 356c, an internal flange 356d, radial passages, 356ea and 356eb, and an end member 356f, having axial passages, 356fa and 356fb.

A shoe 358 defining an internal passage 358a for receiving the valve seat mounting element 356 includes a first threaded annular recess 358b, and a second threaded annular recess 358c for engaging the threaded portion 320d of the expansion cone launcher 320, at one end, a first threaded counterbore 358d for engaging the threaded portion 356c of the of the valve seat mounting element, and a second counterbore 358e for mating with the end member 356f of the mounting element. In a preferred embodiment, the shoe 358 is fabricated from a ceramic and/or a composite material in order to facilitate the subsequent removal of the shoe by drilling.

A seventh tubular support member 360 defining an internal passage 360a for receiving the sliding sleeve 342 and the valve members 344, 346, and

348 is positioned within the expansion cone launcher 320 that includes an internally threaded portion 360b at one end for engaging the externally threaded portion of the annular recess 358b of the shoe 358. In a preferred embodiment, during operation of the assembly, the end of the seventh tubular support member 360 limits the longitudinal movement of the expansion cone 318 in the direction of the shoe 358 by limiting the longitudinal movement of the sixth tubular support member 338. An annular centralizer 362 defining an internal passage 362 for supporting the valve member 348 is positioned within the seventh tubular support member 360 that includes axial passages 362b and 362c.

Referring to Figs. 19a-19b, during operation, the assembly 300 may be used to form or repair a wellbore casing by implementing a method 400 in which, as illustrated in Figs. 20a-20c, the assembly 300 may initially be positioned within a wellbore 1000 having a preexisting wellbore casing 1002 by coupling a conventional tubular member 1004 defining an internal passage 1004a to the threaded portion 312b of the first tubular support member 312 in step 402. In a preferred embodiment, during placement of the assembly 300 within the wellbore 1000, fluidic materials 1006 within the wellbore 1000 below the assembly 300 are conveyed through the assembly 300 and into the passage 1004a by the fluid passages 356fa, 356fb, 352a, 348a, 346a, 344a, and 314a. In this manner, surge pressures that can be created during placement of the assembly 300 within the wellbore 1000 are minimized. In a preferred embodiment, the float valve element 354 is pre-set in an auto-fill configuration to permit the fluidic materials 1006 to pass through the conical passage 352a of the valve seat 352.

Referring to Figs. 21a-21c, in step 404, fluidic materials 1008 may then be injected into and through the tubular member 1004 and assembly 300 to thereby ensure that all of the fluid passages 1004a, 314a, 344a, 346a, 348a, 352a, 356fa, and 356fb are functioning properly.

Referring to Figs. 22a-22c, in step 406, a bottom plug 1010 may then be injected into the fluidic materials 1008 and into the assembly 300 and then positioned in the throat passage 346aa of the valve member 346. In this

manner, the region of the passage 346a upstream from the plug 1010 may be fluidicly isolated from the region of the passage 346a downstream from the plug 1010. In a preferred embodiment, the proper placement of the plug 1010 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1008.

Referring to Figs. 23a-23c, in step 408, the sliding sleeve 342 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by applying, for example, a downward force of approximately 5,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the plug 1010 may bypass the plug by passing through the first passages, 344da and 344db, through the annular passage 342a, through the second passages, 344fa and 344fb, through the annular passage 350, through the passages, 346ca and 346cb, into the region of the passage 348a downstream from the plug. Furthermore, in this manner, the rupture disc 336 is fluidicly isolated from the passages 314a and 344a.

Referring to Figs. 24a-24c, in step 410, a hardenable fluidic sealing material 1012 may then be injected into the assembly 300 and conveyed through the passages 1004a, 314a, 344a, 344da, 344db, 342a, 344fa, 344fb, 350, 346ca, 346cb, 348a, 352a, 356fa, and 356fb into the wellbore 1000. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 320 and the wellbore 1000 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 320. Furthermore, in this manner, the radial passage 330a and the rupture disc 336 are not exposed to the hardenable fluidic sealing material 1012.

Referring to Figs. 25a-25c, in step 412, upon the completion of the injection of the hardenable fluidic sealing material 1012, a nonhardenable fluidic material 1014 may be injected into the assembly 300, and a top plug 1016 may then be injected into the assembly 300 along with the fluidic materials 1014 and then positioned in the throat passage 344aa of the valve member 344. In this manner, the region of the passage 344a upstream from the top plug 1016 may be fluidicly isolated from region downstream from the top plug. In a preferred embodiment, the proper placement of the plug 1016 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1014.

Referring to Fig. 26a-26c, in step 414, the sliding sleeve 42 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by applying, for example, an upward force of approximately 13,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 1010 may no longer bypass the bottom plug by passing through the first passages, 344da and 344db, through the annular passage 342a, through the second passages, 344fa and 344fb, through the annular passage 350, and through the passages, 346ca and 346cb, into region of the passage 348a downstream from the bottom plug. Furthermore, in this manner, the rupture disc 336 is no longer fluidicly isolated from the fluid passages 314a and 344a.

Referring to Figs. 27a-27c, in step 416, the fluidic material 1014 may be injected into the assembly 300. The continued injection of the fluidic material 1014 may increase the operating pressure within the passages 314a and 344a until the burst disc 336 is opened thereby permitting the pressurized fluidic material 1014 to pass through the radial passage 330a and into an annular

region 1018 defined by the second tubular support member 314, the third tubular support member 316, the sixth tubular support member 338, the collet 340, the sliding sleeve 342, the valve members, 344 and 348, the shoe 358, and the seventh tubular support member 360. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn is applied to the expansion cone 318. In this manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby radially expanding and plastically deforming the expansion cone launcher.

In an alternative embodiment of the method 400, the injection and placement of the top plug 1016 into the liner hanger assembly 300 in step 412 may omitted.

In an alternative embodiment of the method 400, in step 402, the assembly 300 is positioned at the bottom of the wellbore 1000.

In an alternative embodiment, as illustrated in Figs. 28a-28b, during operation, the assembly 300 may be used to form or repair a wellbore casing by implementing a method 450 in which, as illustrated in Figs. 20a-20c, the assembly 300 may initially be positioned within a wellbore 1000 having a preexisting wellbore casing 1002 by coupling a conventional tubular member 1004 defining an internal passage 1004a to the threaded portion 312b of the first tubular support member 312 in step 452. In a preferred embodiment, during placement of the assembly 300 within the wellbore 1000, fluidic materials 1006 within the wellbore 1000 below the assembly 300 are conveyed through the assembly 300 and into the passage 1004a by the fluid passages 356fa, 356fb, 352a, 348a, 346a, 344a, and 314a. In this manner, surge pressures that can be created during placement of the assembly 300 within the wellbore 1000 are minimized. In a preferred embodiment, the float valve element 354 is pre-set in an auto-fill configuration to permit the fluidic materials 1006 to pass through the conical passage 352a of the valve seat 352.

Referring to Figs. 21a-21c, in step 454, in step 454, fluidic materials 1008 may then be injected into and through the tubular member 1004 and assembly

300 to thereby ensure that all of the fluid passages 1004a, 314a, 344a, 346a, 348a, 352a, 356fa, and 356fb are functioning properly.

Referring to Figs. 22a-22c, in step 456, the bottom plug 1010 may then be injected into the fluidic materials 1008 and into the assembly 300 and then positioned in the throat passage 346aa of the valve member 346. In this manner, the region of the passage 346a upstream from the plug 1010 may be fluidicly isolated from the region of the passage 346a downstream from the plug 1010. In a preferred embodiment, the proper placement of the plug 1010 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1008.

Referring to Figs. 29a-29c, in step 458, the fluidic material 1014 may then be injected into the assembly 300 to thereby increase the operating pressure within the passages 314a and 344a until the burst disc 336 is opened thereby permitting the pressurized fluidic material 1014 to pass through the radial passage 330a and into an annular region 1018 defined by the defined by the second tubular support member 314, the third tubular support member 316, the sixth tubular support member 338, the collet 340, the sliding sleeve 342, the valve members, 344 and 348, the shoe 358, and the seventh tubular support member 360. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn is applied to the expansion cone 318. In this manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby disengaging the collet 340 and the sliding sleeve 342 and radially expanding and plastically deforming the expansion cone launcher. In a preferred embodiment, the radial expansion process in step 458 is continued to a location below the overlap between the expansion cone launcher 320 and the preexisting wellbore casing 1002.

Referring to Figs. 30a-30c, in step 460, the sliding sleeve 342 may then be displaced relative to the valve member 344 by (1) displacing the expansion cone 318 in a downward direction using the tubular member 1004 and (2) applying, using the tubular member 1004 a downward force of, for example,

approximately 5,000 lbf on the assembly 300. In this manner, the coupling 340b of the collet 340 reengages the external groove 342e of the sliding sleeve 342. Furthermore, in this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 1010 may bypass the plug by passing through the passages, 344da and 344db, the annular passage 342a, the passages, 344fa and 344fb, the annular passage 350, and the passages, 346ca and 346cb, into the passage 348a downstream from the plug. Furthermore, in this manner, the fluid passage 330a is fluidicly isolated from the passages 314a and 344a.

Referring to Figs. 31a-31c, in step 462, the hardenable fluidic sealing material 1012 may then be injected into the assembly 300 and conveyed through the passages 1004a, 314a, 344a, 344da, 344db, 342, 344fa, 344fb, 350, 346ca, 346cb, 348a, 352b, 356fa, and 356fb into the wellbore 1000. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 320 and the wellbore 1000 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 320. Furthermore, in this manner, the radial passage 330a and the rupture disc 336 are not exposed to the hardenable fluidic sealing material 1012.

Referring to Figs. 32a-32c, in step 464, upon the completion of the injection of the hardenable fluidic sealing material 1012, the nonhardenable fluidic material 1014 may be injected into the assembly 300, and the top plug 1016 may then be injected into the assembly 300 along with the fluidic materials 1014 and then positioned in the throat passage 344aa of the valve member 344. In this manner, the region of the passage 344a upstream from the top plug 1016 may be fluidicly isolated from the region within the passage

downstream from the top plug. In a preferred embodiment, the proper placement of the plug 1016 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1014.

Referring to Figs. 33a-33c, in step 466, the sliding sleeve 342 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by applying, for example, an upward force of approximately 13,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 110 may no longer bypass the plug by passing through the passages, 344da and 344db, the annular passage 342a, the passages, 344fa and 344fb, the annular passage 350, and the passages, 346ca and 346cb, into the passage 348a downstream from the plug. Furthermore, in this manner, the passage 330a is no longer fluidicly isolated from the fluid passages 314a and 344a.

Referring to Figs. 34a-34c, in step 468, the fluidic material 1014 may be injected into the assembly 300. The continued injection of the fluidic material 1014 may increase the operating pressure within the passages 314a, 330a, and 344a and the annular region 1018. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn is applied to the expansion cone 318. In this manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby completing the radial expansion of the expansion cone launcher.

In an alternative embodiment of the method 450, the injection and placement of the top plug 1016 into the liner hanger assembly 300 in step 464 may omitted.

In an alternative embodiment of the method 450, in step 452, the assembly 300 is positioned at the bottom of the wellbore 1000.

In an alternative embodiment of the method 450: (1) in step 452, the assembly 300 is positioned proximate a position below a preexisting section of the wellbore casing 1002, and (2) in step 458, the expansion cone launcher 320, and any expandable tubulars coupled to the threaded portion 320c of the expansion cone launcher, are radially expanded and plastically deformed until the shoe 358 of the assembly 300 is proximate the bottom of the wellbore 1000. In this manner, the radial expansion process using the assembly 300 provides a telescoping of the radially expanded tubulars into the wellbore 1000.

In several alternative embodiments, the assembly 300 may be operated to form a wellbore casing by including or excluding the float valve 354.

In several alternative embodiments, the float valve 354 may be operated in an auto-fill configuration in which tabs are positioned between the float valve 354 and the valve seat 352. In this manner, fluidic materials within the wellbore 1000 may flow into the assembly 300 from below thereby decreasing surge pressures during placement of the assembly 300 within the wellbore 1000. Furthermore, pumping fluidic materials through the assembly 300 at rate of about 6 to 8 bbl/min will displace the tabs from the valve seat 352 and thereby allow the float valve 354 to close.

In several alternative embodiments, prior to the placement of any of the plugs, 1010 and 1016, into the assembly 300, fluidic materials can be circulated through the assembly 300 and into the wellbore 1000.

In several alternative embodiments, once the bottom plug 1010 has been positioned into the assembly 300, fluidic materials can only be circulated through the assembly 300 and into the wellbore 1000 if the sliding sleeve 342 is in the down position.

In several alternative embodiments, once the sliding sleeve 342 is positioned in the down position, the passage 330a and rupture disc 336 are fluidicly isolated from pressurized fluids within the assembly 300.

In several alternative embodiments, once the top plug 1016 has been positioned into the assembly 300, no fluidic materials can be circulated through the assembly 300 and into the wellbore 1000.

In several alternative embodiments, the assembly 300 may be operated to form or repair a wellbore casing, a pipeline, or a structural support.

In a preferred embodiment, the design and operation of the liner hanger assemblies 10 and 300 are provided substantially as described and illustrated in Appendix A to the present application.

In a preferred embodiment, the design and operation of the liner hanger assemblies 10 and 300 are provided substantially as described in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) U.S. patent application serial no. ___________, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. _____________, attorney docket no.

25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. ___________, attorney docket no. 25791.45, filed on 7/28/2000, and (19) U.S. provisional patent application serial no. ___________, attorney docket no. 25791.46, filed on 7/28/2000, the disclosures of which are incorporated herein by reference.

A method of forming a wellbore casing within a borehole within a subterranean formation has been described that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the method further includes fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the borehole includes means for positioning an end of the expandable tubular

member adjacent to the bottom of the borehole. In an exemplary embodiment, the apparatus further includes means for fluidicly isolating the second region from a third region within the expandable tubular member.

A method of forming a wellbore casing within a borehole within a subterranean formation has also been described that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the method further includes fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable

tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the borehole includes means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the means for positioning the expandable tubular member within the borehole includes means for positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, the means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the apparatus further includes means for fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly

coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

An apparatus for forming a wellbore casing in a borehole in a subterranean formation has also been described that includes means for radially expanding an expandable tubular member, and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole. In an exemplary embodiment, the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole includes a sliding sleeve valve.

A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular

valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to

apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member includes injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

A method of coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes positioning an expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, fluidicly coupling the first and

second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the method further includes fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the apparatus further includes means for fluidicly isolating the second region from a third region within the expandable tubular member.

A method of coupling an expandable tubular member to a preexisting structure has also been described that includes positioning the expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidicly isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially

expand at least a portion of the tubular member, fluidicly coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidicly decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element within the preexisting structure. In an exemplary embodiment, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the method further includes fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidicly isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidicly coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidicly decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular

member to radially expand another portion of the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member adjacent to a preexisting structural element within the preexisting structure. In an exemplary embodiment, the means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the apparatus further includes means for fluidicly isolating the second region from a third region within the expandable tubular member.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the

region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for radially expanding an expandable tubular member, and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole. In an exemplary embodiment, the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole includes a sliding sleeve valve.

A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom

throat passage, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the

first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidicly couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidicly decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element casing within the preexisting structure. In an exemplary embodiment, injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member includes injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

Although this detailed description has shown and described illustrative embodiments of the invention, this description contemplates a wide range of modifications, changes, and substitutions. In some instances, one may employ some features of the present invention without a corresponding use of the other features. Accordingly, it is appropriate that readers should construe the

appended claims broadly, and in a manner consistent with the scope of the invention.

Claims

What is claimed is:

1. A method of forming a wellbore casing within a borehole within a subterranean formation, comprising:

positioning an expandable tubular member within the borehole;

injecting fluidic materials into the expandable tubular member;

fluidicly isolating a first region from a second region within the expandable tubular member;

fluidicly coupling the first and second regions;

injecting a hardenable fluidic sealing material into the expandable tubular member;

fluidicly decoupling the first and second regions; and

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

2. The method of claim 1, wherein positioning the expandable tubular member within the borehole comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

3. The method of claim 1, further comprising:

fluidicly isolating the second region from a third region within the expandable tubular member.

4. An apparatus for forming a wellbore casing within a borehole within a subterranean formation, comprising:

means for positioning an expandable tubular member within the borehole;

means for injecting fluidic materials into the expandable tubular member;

means for fluidicly isolating a first region from a second region within the expandable tubular member;

means for fluidicly coupling the first and second regions;

means for injecting a hardenable fluidic sealing material into the expandable tubular member;

means for fluidicly decoupling the first and second regions; and

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

5. The apparatus of claim 4, wherein the means for positioning the expandable tubular member within the borehole comprises:

means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

6. The apparatus of claim 4, further comprising:

means for fluidicly isolating the second region from a third region within the expandable tubular member.

7. A method of forming a wellbore casing within a borehole within a subterranean formation, comprising:

positioning an expandable tubular member within the borehole;

injecting fluidic materials into the expandable tubular member;

fluidicly isolating a first region from a second region within the expandable tubular member;

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;

fluidicly coupling the first and second regions;

injecting a hardenable fluidic sealing material into the expandable tubular member;

fluidicly decoupling the first and second regions; and

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

8. The method of claim 7, wherein positioning the expandable tubular member within the borehole comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

9. The method of claim 7, wherein positioning the expandable tubular member within the borehole comprises:

positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.

10. The method of claim 7, wherein injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.

11. The method of claim 7, further comprising:

fluidicly isolating the second region from a third region within the expandable tubular member.

12. An apparatus for forming a wellbore casing within a borehole within a subterranean formation, comprising:

means for positioning an expandable tubular member within the borehole;

means for injecting fluidic materials into the expandable tubular member;

means for fluidicly isolating a first region from a second region within the expandable tubular member;

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;

means for fluidicly coupling the first and second regions;

means for injecting a hardenable fluidic sealing material into the expandable tubular member;

means for fluidicly decoupling the first and second regions; and

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

13. The apparatus of claim 12, wherein means for positioning the expandable tubular member within the borehole comprises:

means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

14. The apparatus of claim 12, wherein means for positioning the expandable tubular member within the borehole comprises:

means for positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.

15. The apparatus of claim 12, wherein means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.

16. The apparatus of claim 12, further comprising:

means for fluidicly isolating the second region from a third region within the expandable tubular member.

17. An apparatus for forming a wellbore casing within a borehole within a subterranean formation, comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

18. An apparatus for forming a wellbore casing in a borehole in a subterranean formation, comprising:

means for radially expanding an expandable tubular member; and

means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

19. The apparatus of claim 18, wherein the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole, comprises:

a sliding sleeve valve.

20. A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

positioning the apparatus within the borehole;

injecting fluidic materials into the first, second and third fluid passages;

positioning a bottom plug in the bottom throat passage;

displacing the annular sleeve to fluidicly couple the second and third radial passages;

injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;

displacing the annular sleeve to fluidicly decouple the second and third radial passages; and

injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

21. The method of claim 20, wherein positioning the apparatus within the borehole comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

22. The method of claim 20, further comprising:

positioning a top plug in the top throat passage.

23. A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular

support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

positioning the apparatus within the borehole;

injecting fluidic materials into the first, second and third fluid passages;

positioning a bottom plug in the bottom throat passage;

injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member;

displacing the annular sleeve to fluidicly couple the second and third radial passages;

injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;

displacing the annular sleeve to fluidicly decouple the second and third radial passages; and

injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

24. The method of claim 23, wherein positioning the apparatus within the borehole comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

25. The method of claim 23, wherein positioning the apparatus within the borehole comprises:

positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.

26. The method of claim 23, wherein injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member comprises:

injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.

27. The method of claim 23, further comprising:

positioning a top plug in the top throat passage.

28. A method of coupling an expandable tubular member to a preexisting structure, comprising:

positioning the expandable tubular member within the preexisting structure;

injecting fluidic materials into the expandable tubular member;

fluidicly isolating a first region from a second region within the expandable tubular member;

fluidicly coupling the first and second regions;

injecting a hardenable fluidic sealing material into the expandable tubular member;

fluidicly decoupling the first and second regions; and

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

29. The method of claim 28, wherein positioning the expandable tubular member within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

30. The method of claim 28, further comprising:

fluidicly isolating the second region from a third region within the expandable tubular member.

31. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:

means for positioning the expandable tubular member within the preexisting structure;

means for injecting fluidic materials into the expandable tubular member;

means for fluidicly isolating a first region from a second region within the expandable tubular member;

means for fluidicly coupling the first and second regions;

means for injecting a hardenable fluidic sealing material into the expandable tubular member;

means for fluidicly decoupling the first and second regions; and

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

32. The apparatus of claim 31, wherein the means for positioning the expandable tubular member within the preexisting structure comprises:

means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

33. The apparatus of claim 31, further comprising:

means for fluidicly isolating the second region from a third region within the expandable tubular member.

34. A method of coupling an expandable tubular member to a preexisting structure, comprising:

positioning the expandable tubular member within the preexisting structure;

injecting fluidic materials into the expandable tubular member;

fluidicly isolating a first region from a second region within the expandable tubular member;

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;

fluidicly coupling the first and second regions;

injecting a hardenable fluidic sealing material into the expandable tubular member;

fluidicly decoupling the first and second regions; and

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

35. The method of claim 34, wherein positioning the expandable tubular member within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

36. The method of claim 34, wherein positioning the expandable tubular member within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to a preexisting tubular structural element within the preexisting structure.

37. The method of claim 34, wherein injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

38. The method of claim 34, further comprising:

fluidicly isolating the second region from a third region within the expandable tubular member.

39. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:

means for positioning the expandable tubular member within the preexisting structure;

means for injecting fluidic materials into the expandable tubular member;

means for fluidicly isolating a first region from a second region within the expandable tubular member;

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;

means for fluidicly coupling the first and second regions;

means for injecting a hardenable fluidic sealing material into the expandable tubular member;

means for fluidicly decoupling the first and second regions; and

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

40. The apparatus of claim 39, wherein means for positioning the expandable tubular member within the preexisting structure comprises:
means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

41. The apparatus of claim 39, wherein means for positioning the expandable tubular member within the preexisting structure comprises:
means for positioning an end of the expandable tubular member adjacent to a preexisting structural element within the preexisting structure.

42. The apparatus of claim 39, wherein means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:
means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

43. The apparatus of claim 39, further comprising:
means for fluidicly isolating the second region from a third region within the expandable tubular member.

44. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

45. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:

means for radially expanding an expandable tubular member; and

means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

46. The apparatus of claim 45, wherein the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole, comprises:

a sliding sleeve valve.

47. A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

positioning the apparatus within the preexisting structure;

injecting fluidic materials into the first, second and third fluid passages;

positioning a bottom plug in the bottom throat passage;

displacing the annular sleeve to fluidicly couple the second and third radial passages;

injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;

displacing the annular sleeve to fluidicly decouple the second and third radial passages; and

injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

48. The method of claim 47, wherein positioning the apparatus within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

49. The method of claim 47, further comprising:

positioning a top plug in the top throat passage.

50. A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidicly coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidicly coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidicly coupled to the third fluid passage, coupled to the second annular

support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidicly coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

positioning the apparatus within the preexisting structure;

injecting fluidic materials into the first, second and third fluid passages;

positioning a bottom plug in the bottom throat passage;

injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member;

displacing the annular sleeve to fluidicly couple the second and third radial passages;

injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;

displacing the annular sleeve to fluidicly decouple the second and third radial passages; and

injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

51. The method of claim 50, wherein positioning the apparatus within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

52. The method of claim 50, wherein positioning the apparatus within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element within the preexisting structure.

53. The method of claim 50, wherein injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member comprises:

injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

54. The method of claim 50, further comprising:

positioning a top plug in the top throat passage.

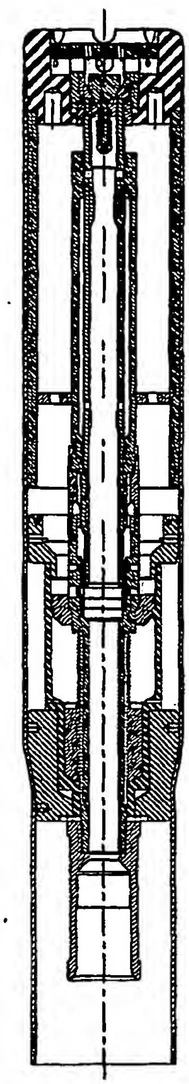

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Fig. 1

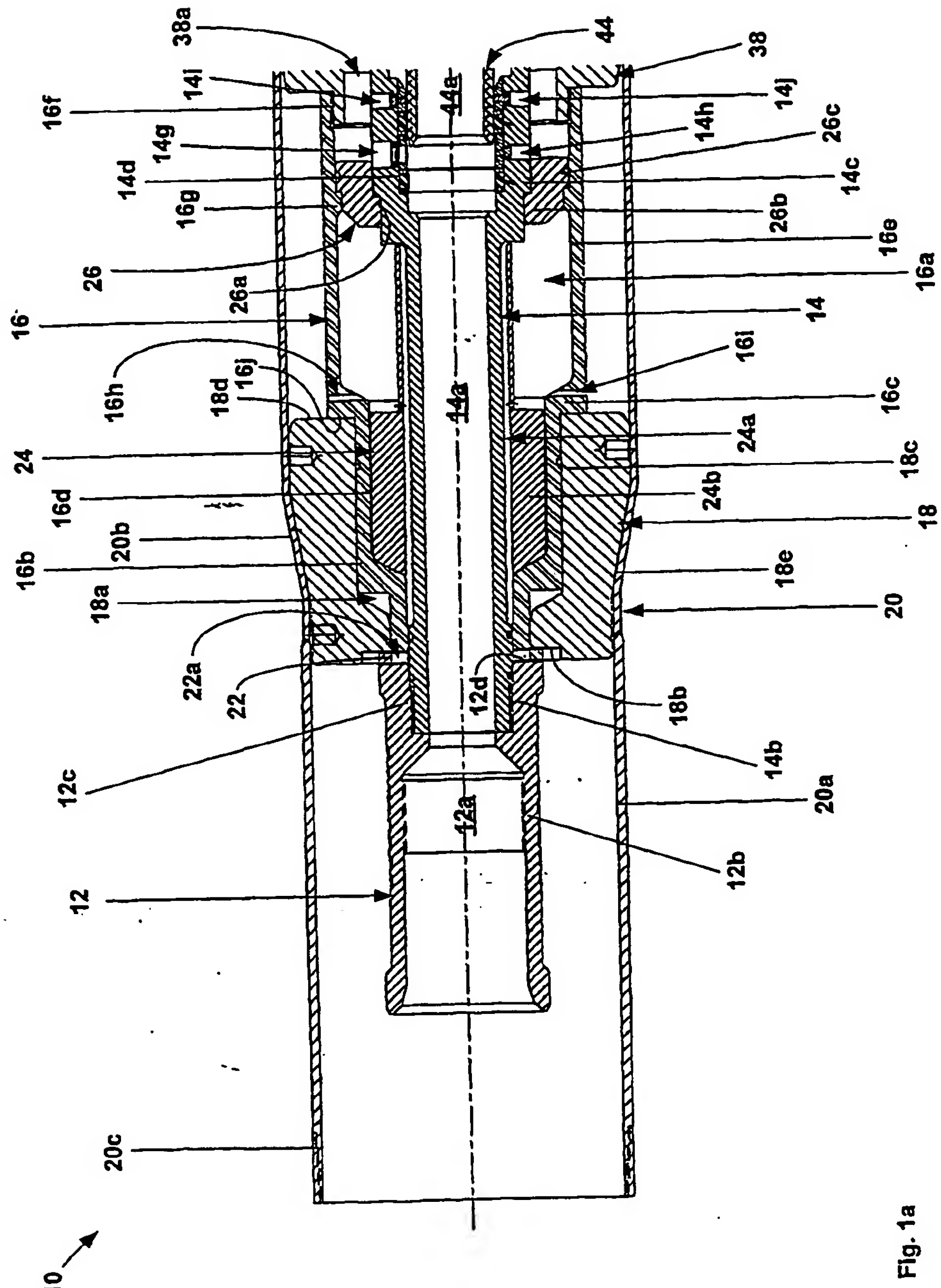
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Fig. 1a

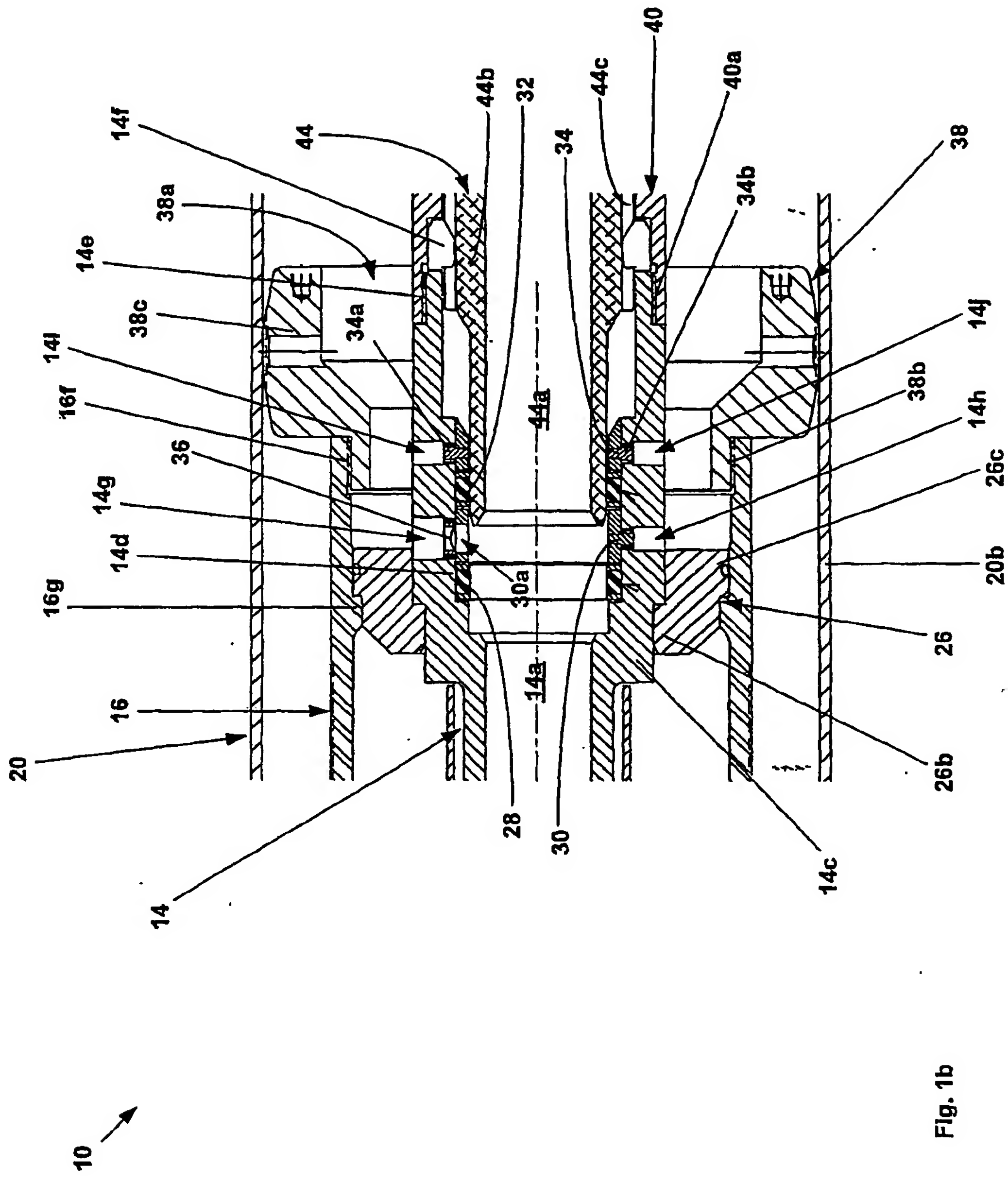
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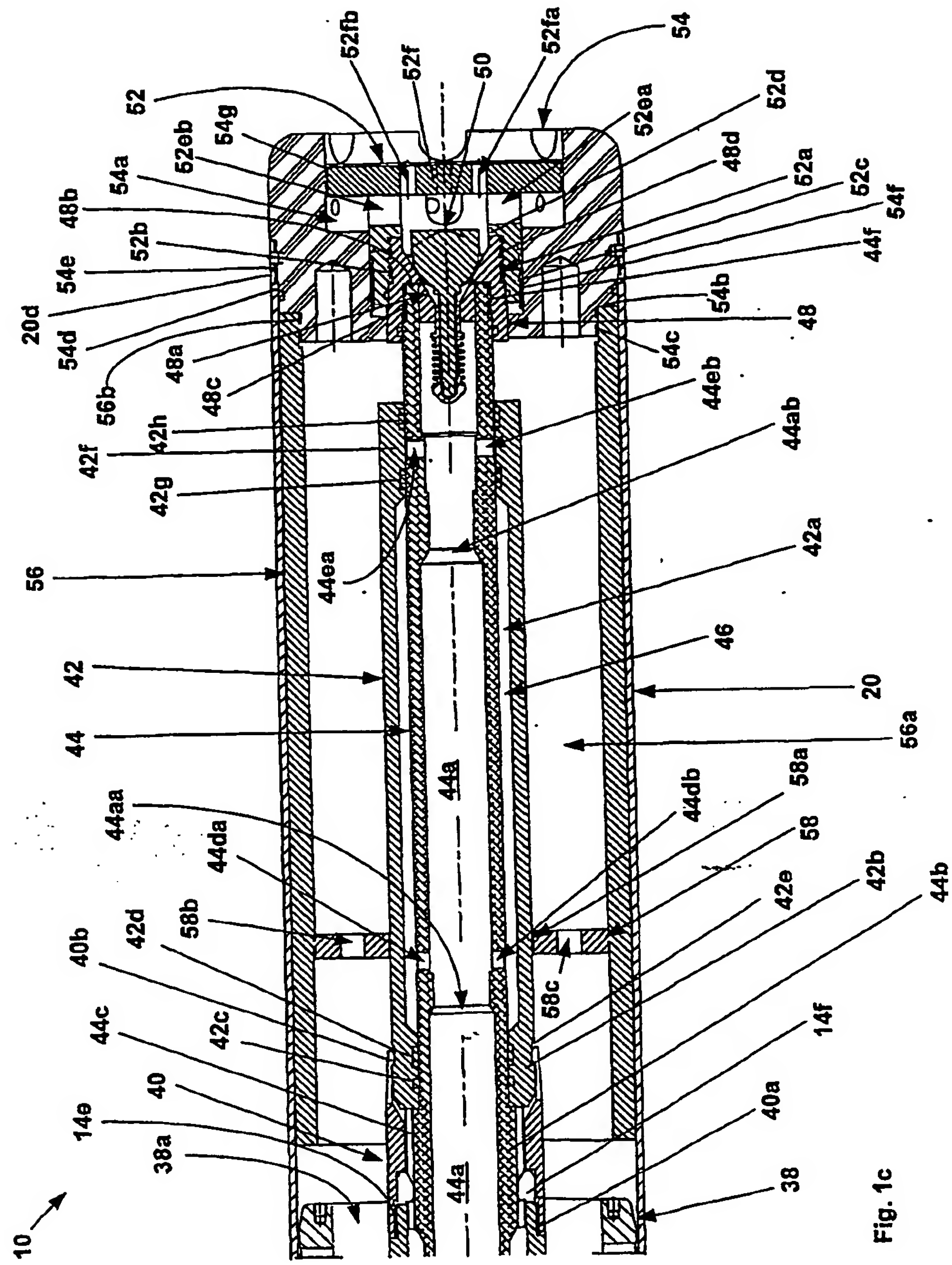
Fig. 1b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40a
14e
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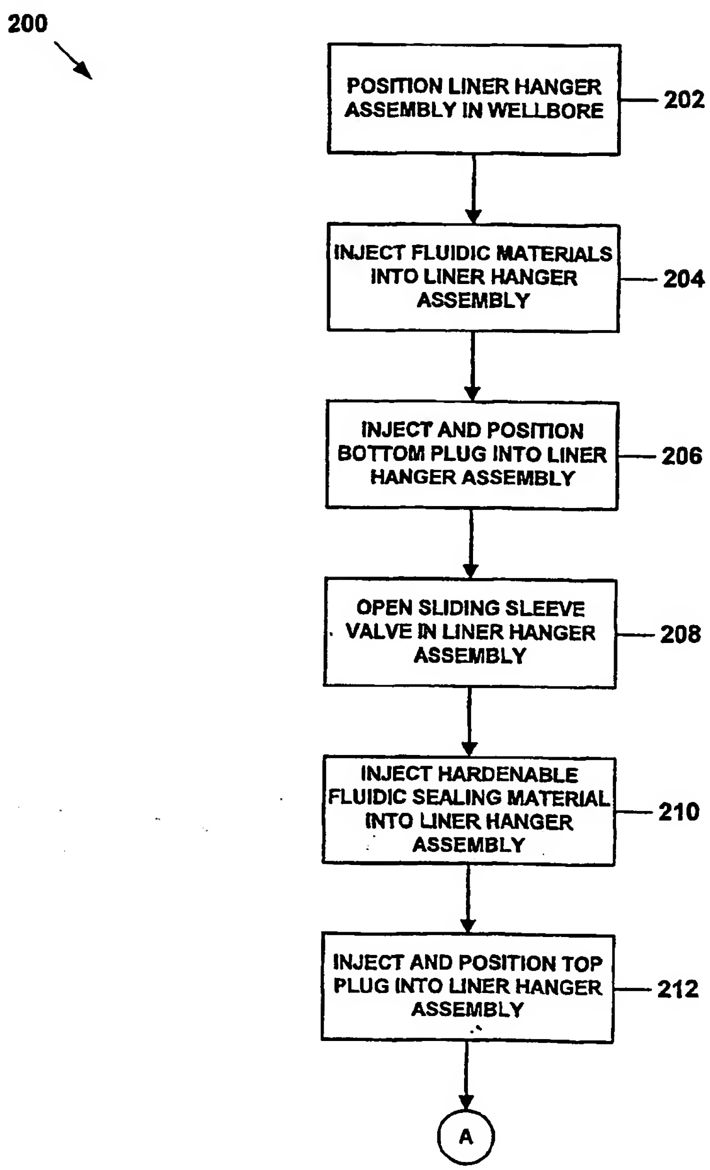
44a
38
10

Fig. 1c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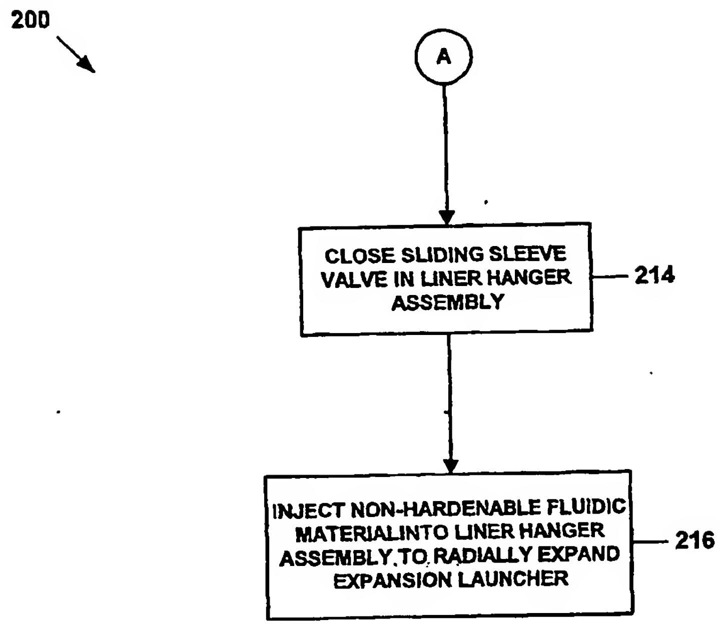
POSITION LINER HANGER ASSEMBLY IN WELLBORE
202
INJECT FLUIDIC MATERIALS INTO LINER HANGER ASSEMBLY
204
INJECT AND POSITION BOTTOM PLUG INTO LINER HANGER ASSEMBLY
206
OPEN SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
208
INJECT HARDENABLE FLUIDIC SEALING MATERIAL INTO LINER HANGER ASSEMBLY
210
INJECT AND POSITION TOP PLUG INTO LINER HANGER ASSEMBLY
212
A

Fig. 2a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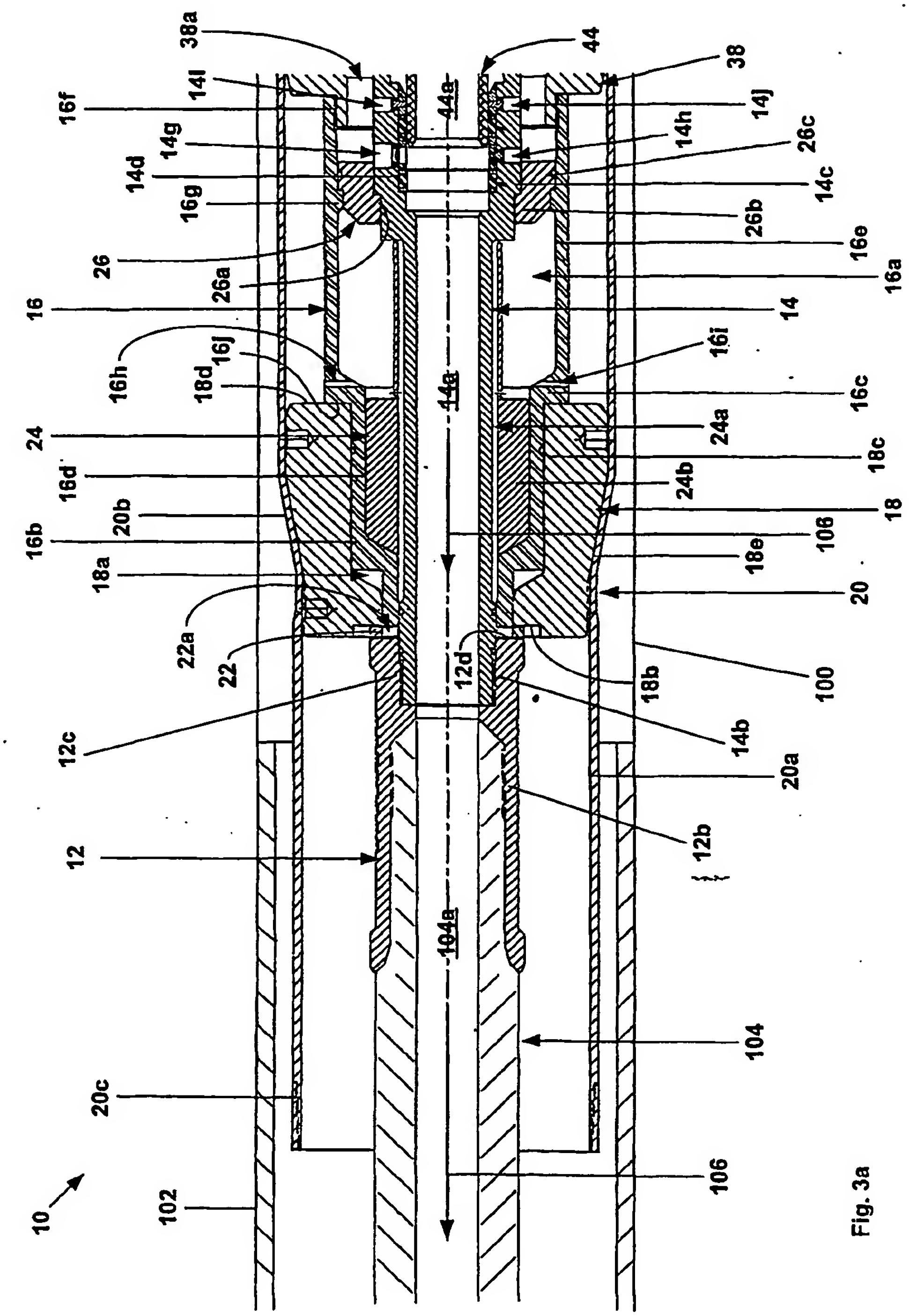
A
CLOSE SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
214
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
216

Fig. 2b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16b
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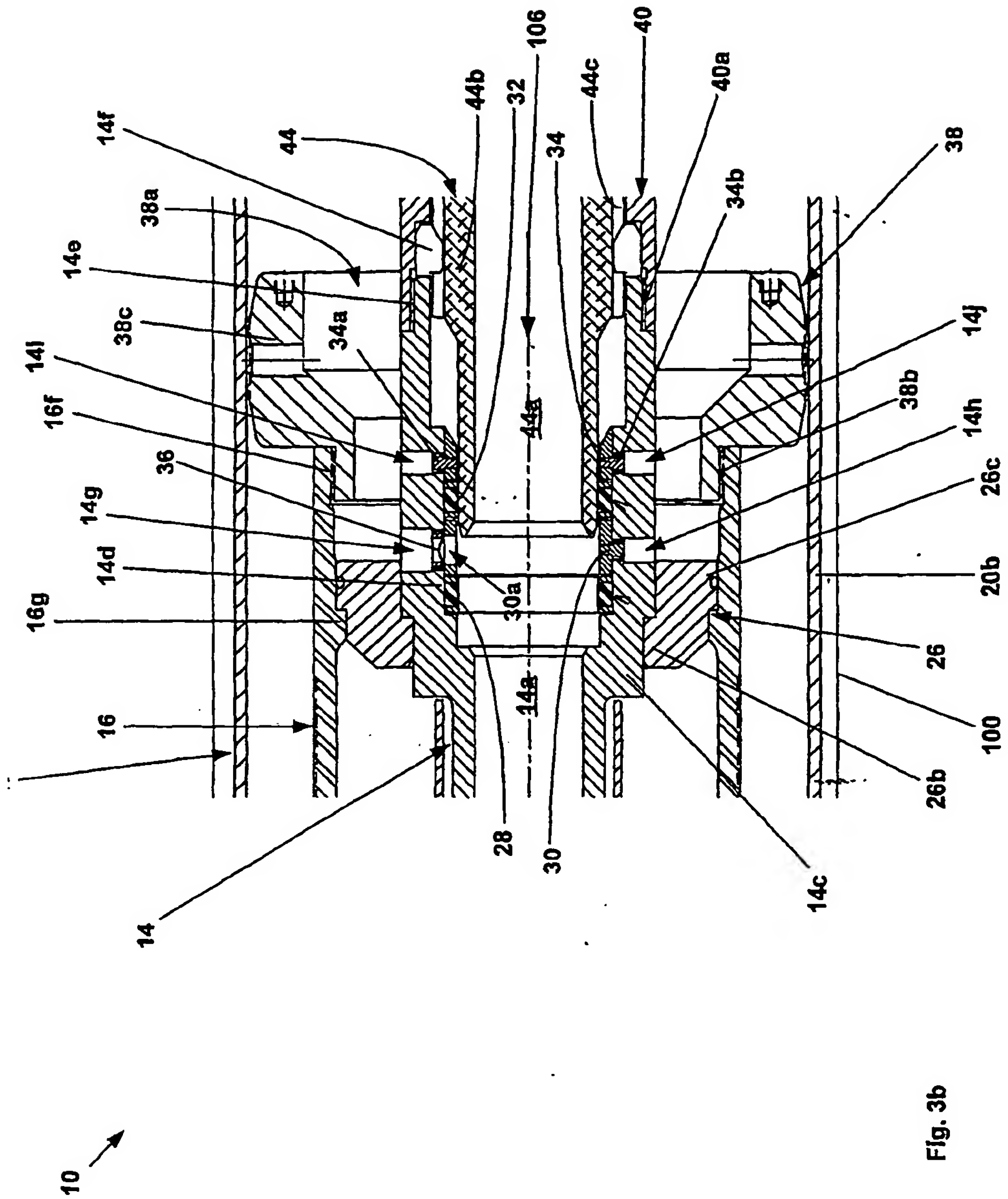
Fig. 3a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14g
14d
16g
16
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20b
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Fig. 3b

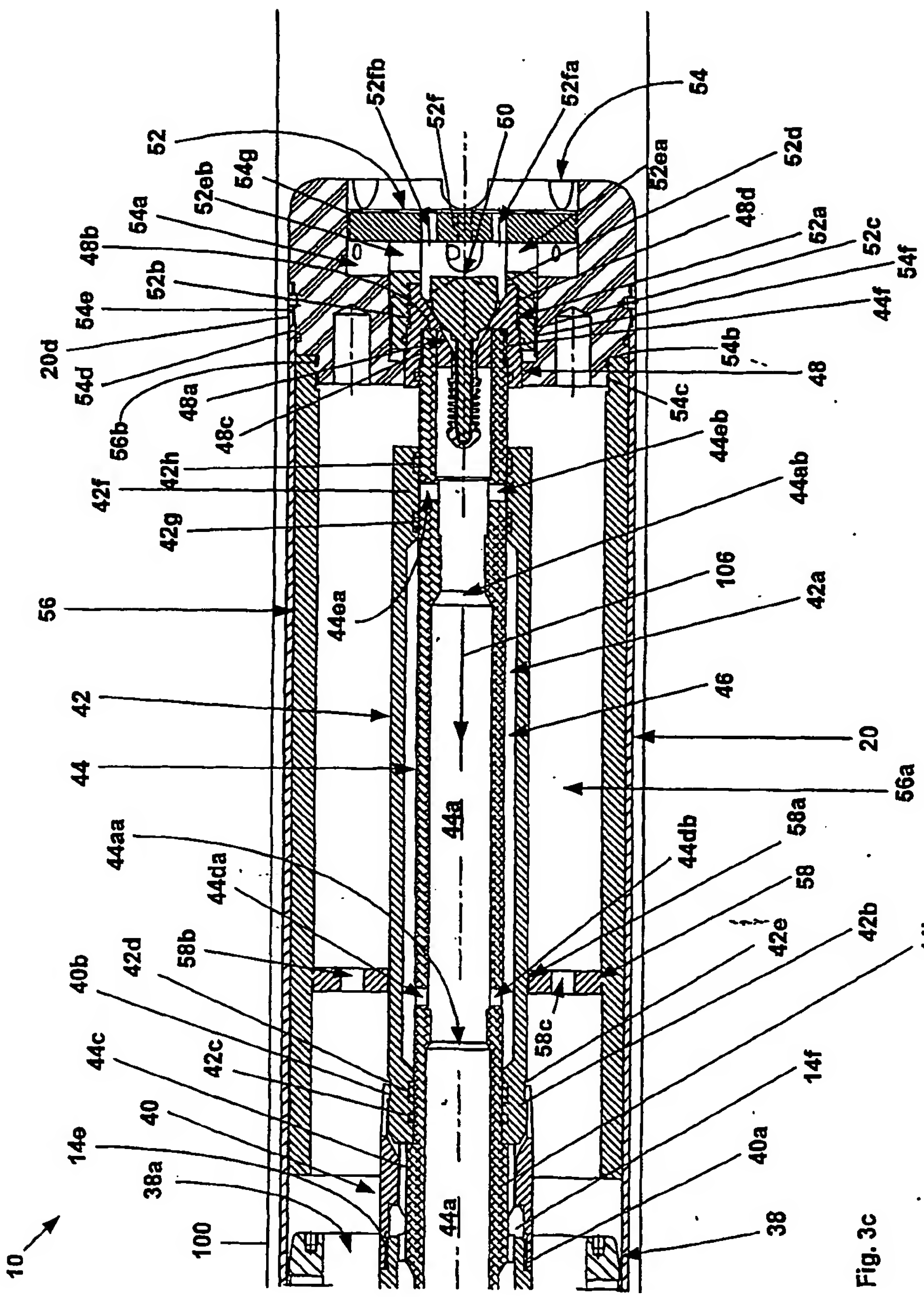
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Fig. 3c

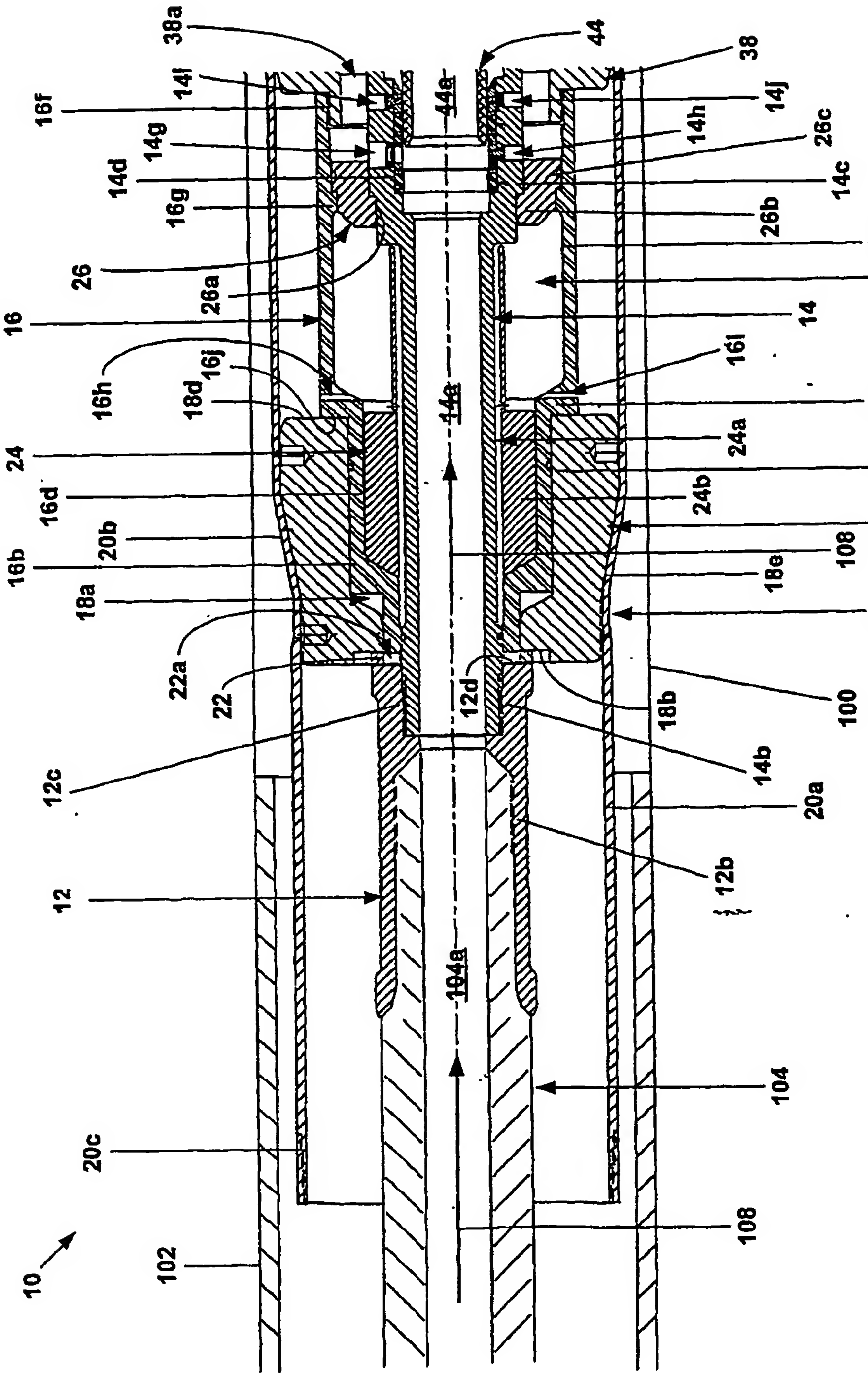
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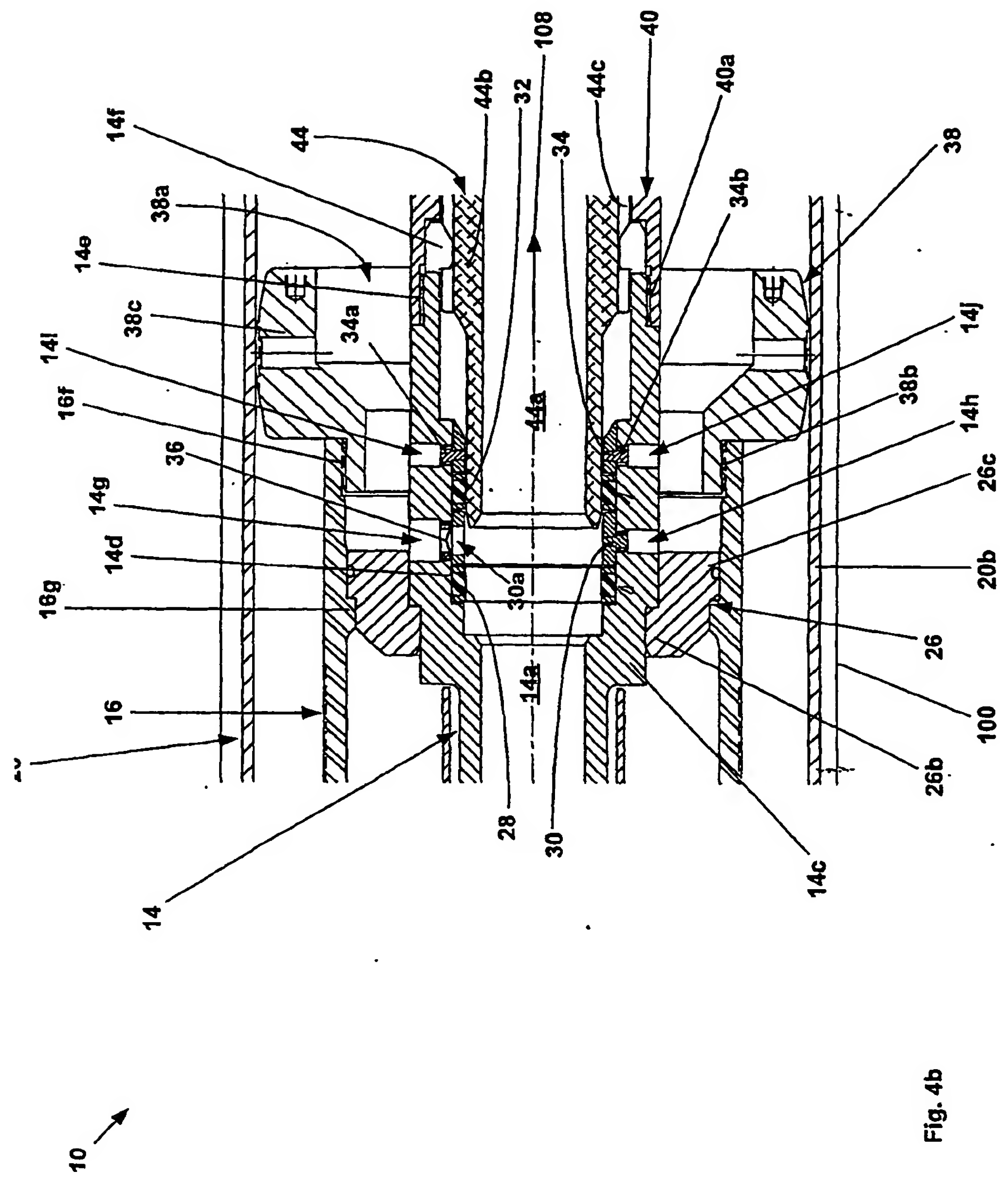
Fig. 4a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14d
16g
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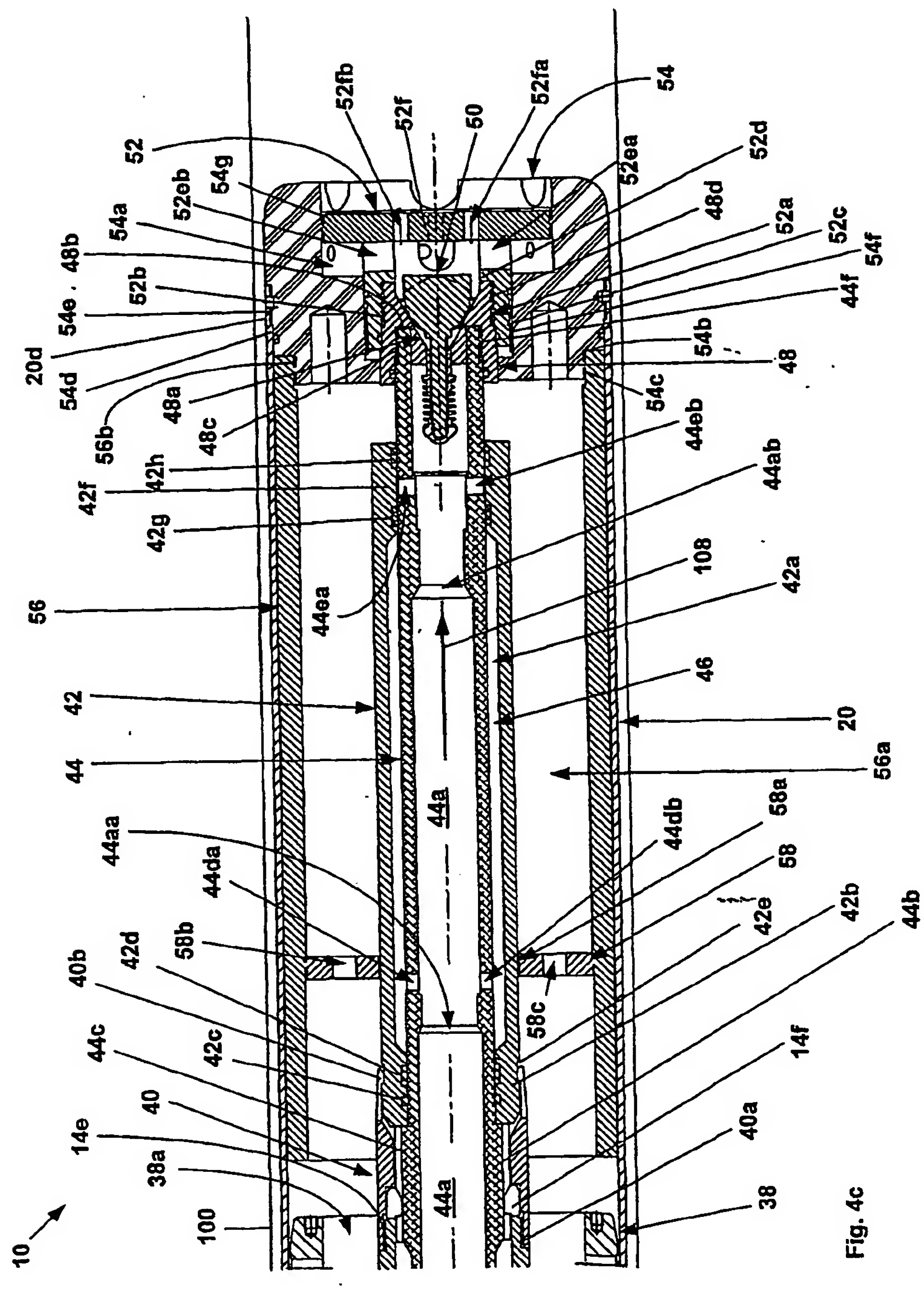
Fig. 4b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44ab
42g
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44ea
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44db
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58b
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40b
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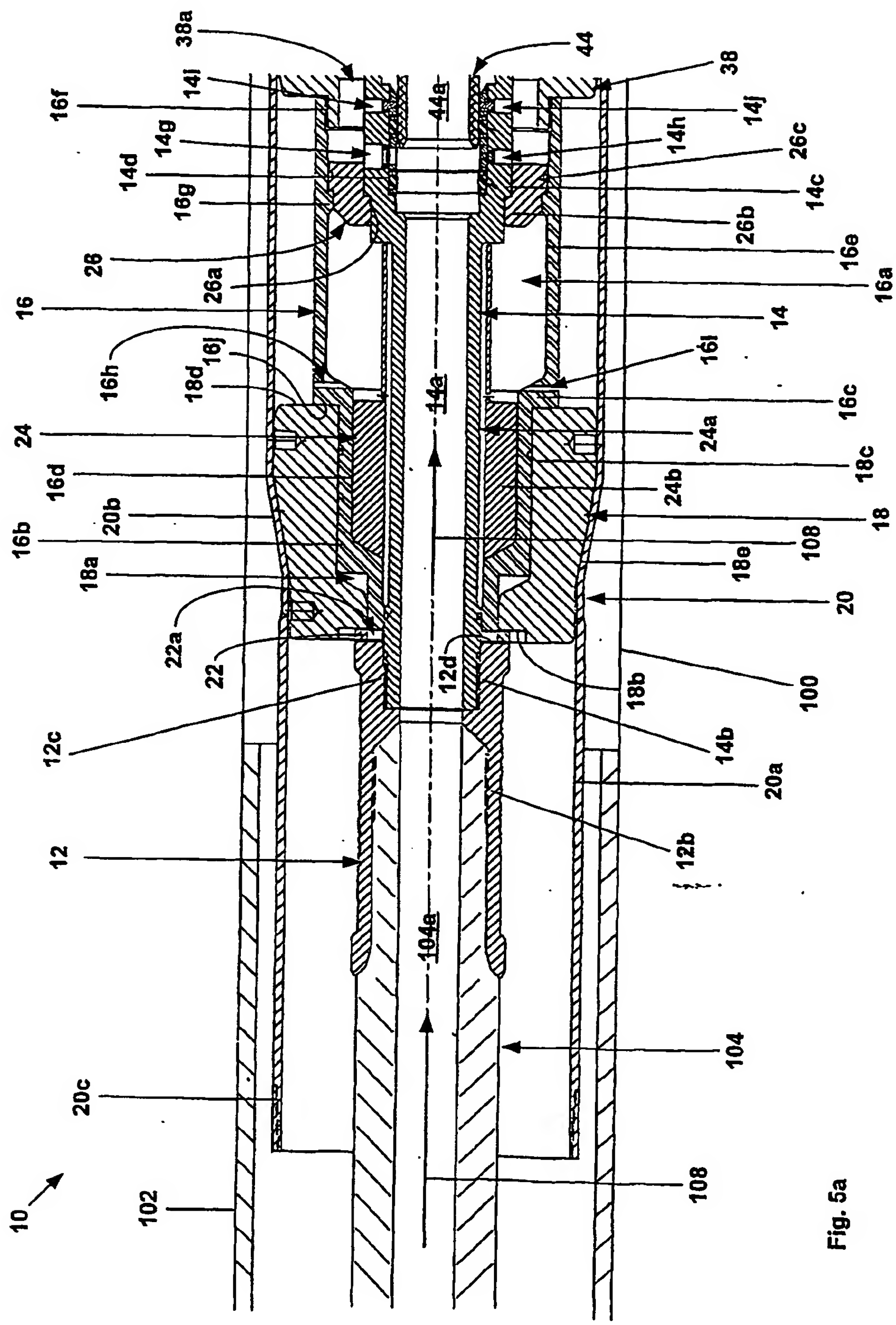
10

Fig. 4c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18
16b
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18e
18a
20
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12b
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10
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Fig. 5a

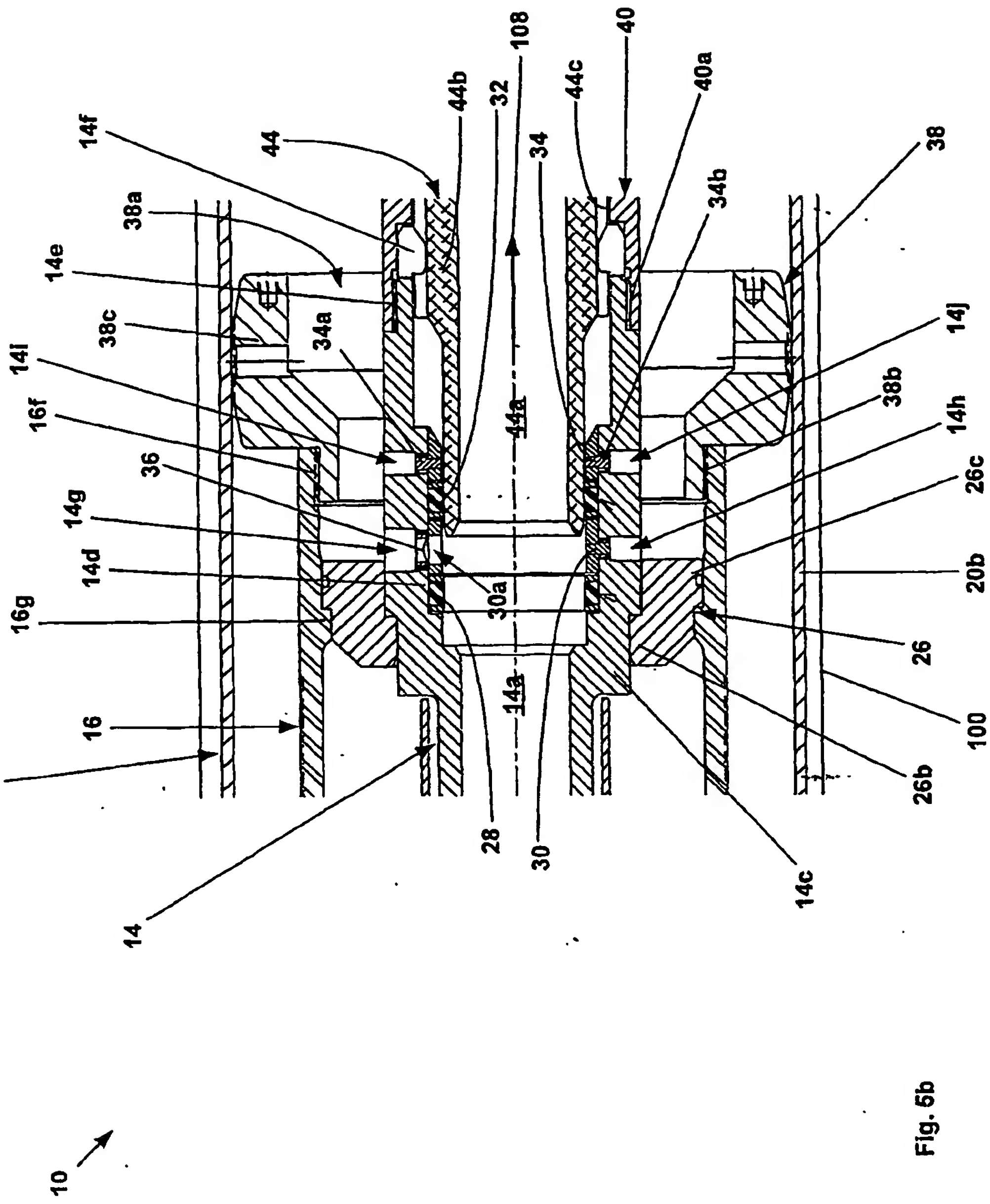
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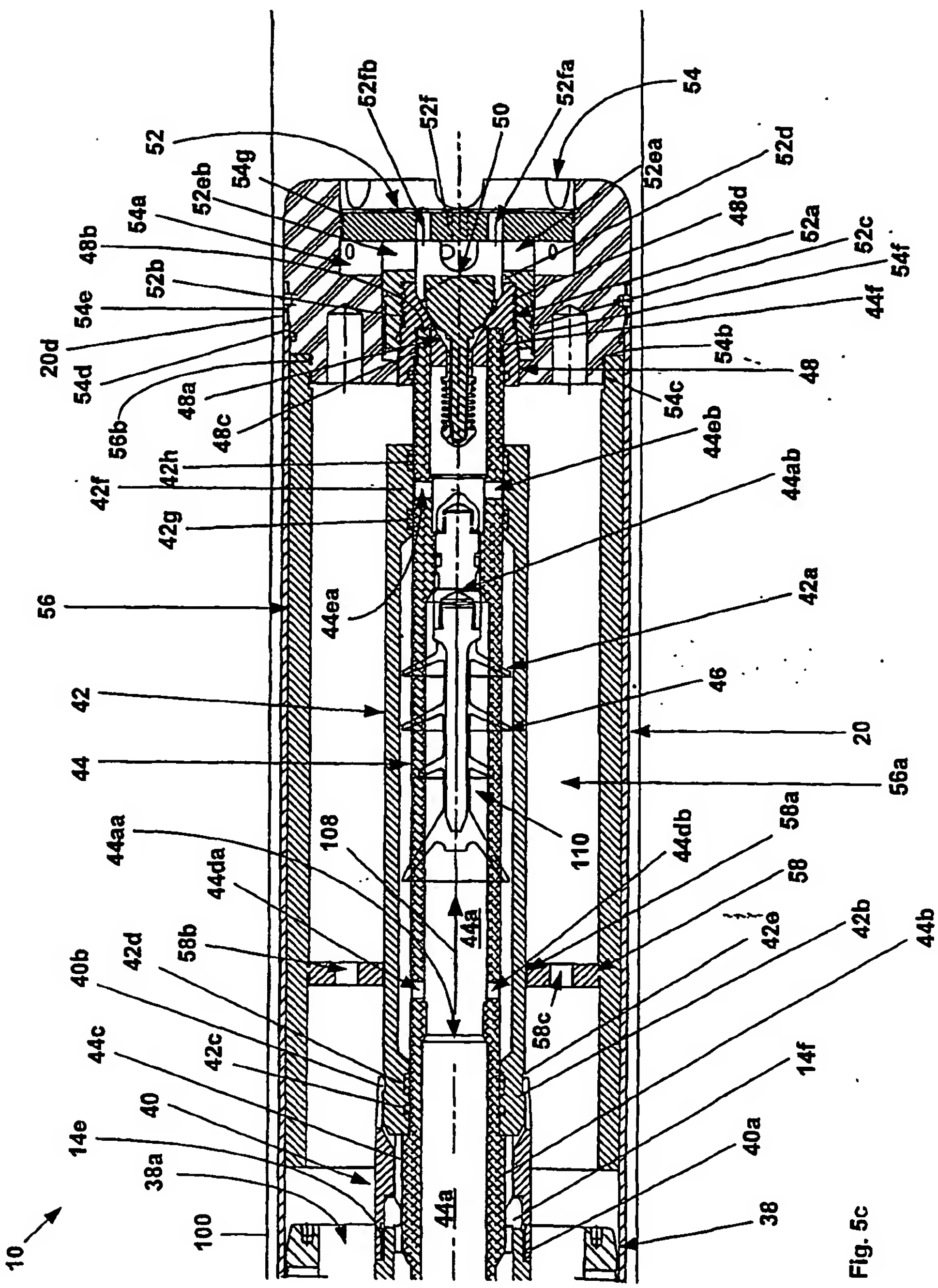
Fig. 5b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44da
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40b
42d
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100
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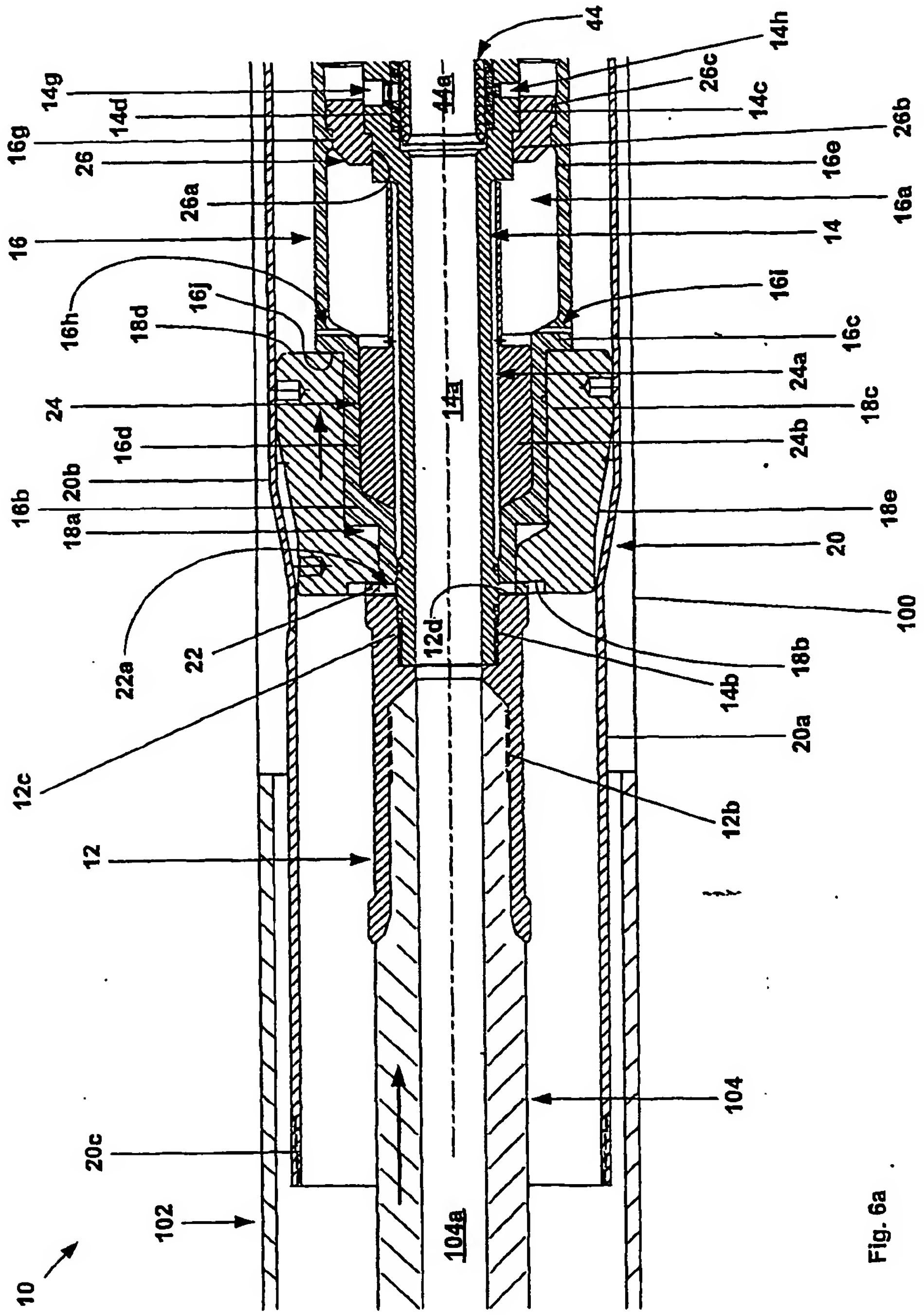
40a
38

Fig. 5c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44a
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104a
12d
14h
26c
14c
26b
16e
16a
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24a
18c
24b
18e
20
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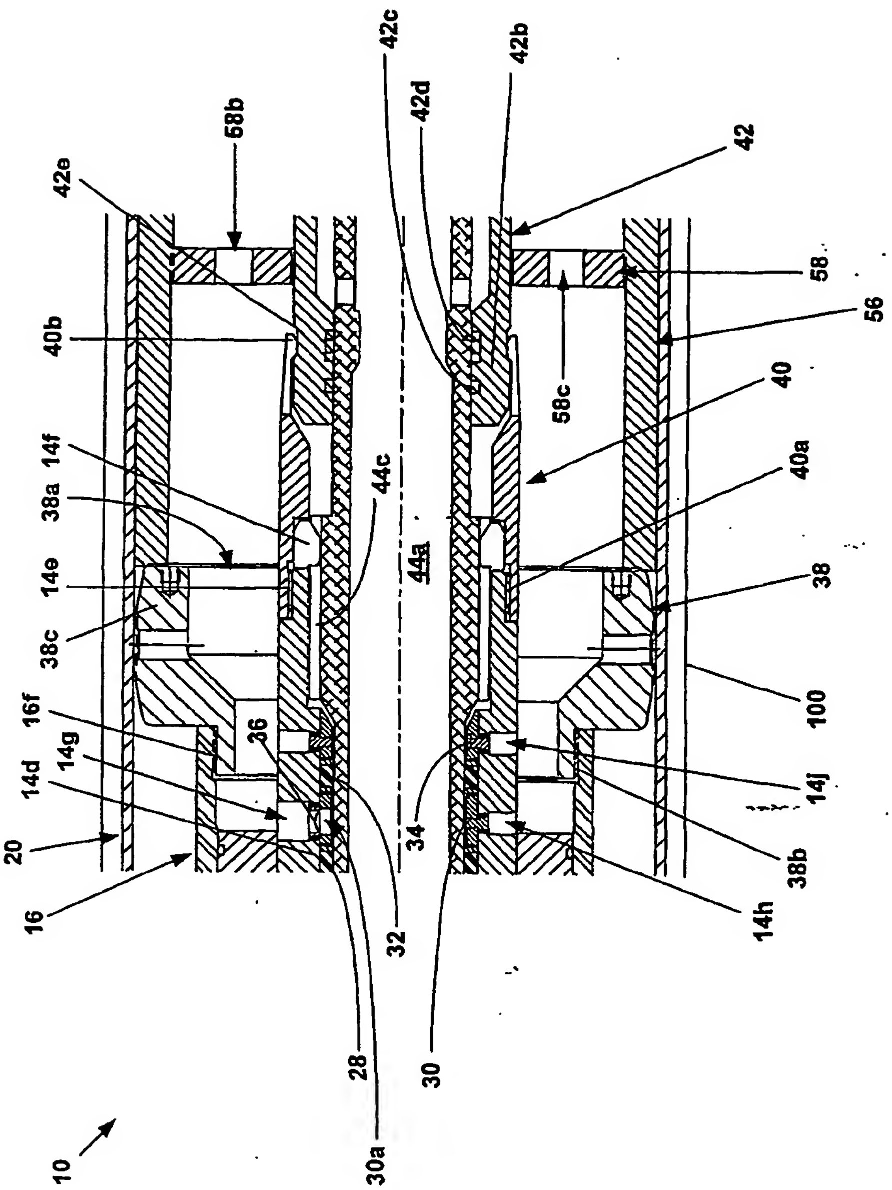
18b
14b
20a
12b
104

Fig. 6a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38c
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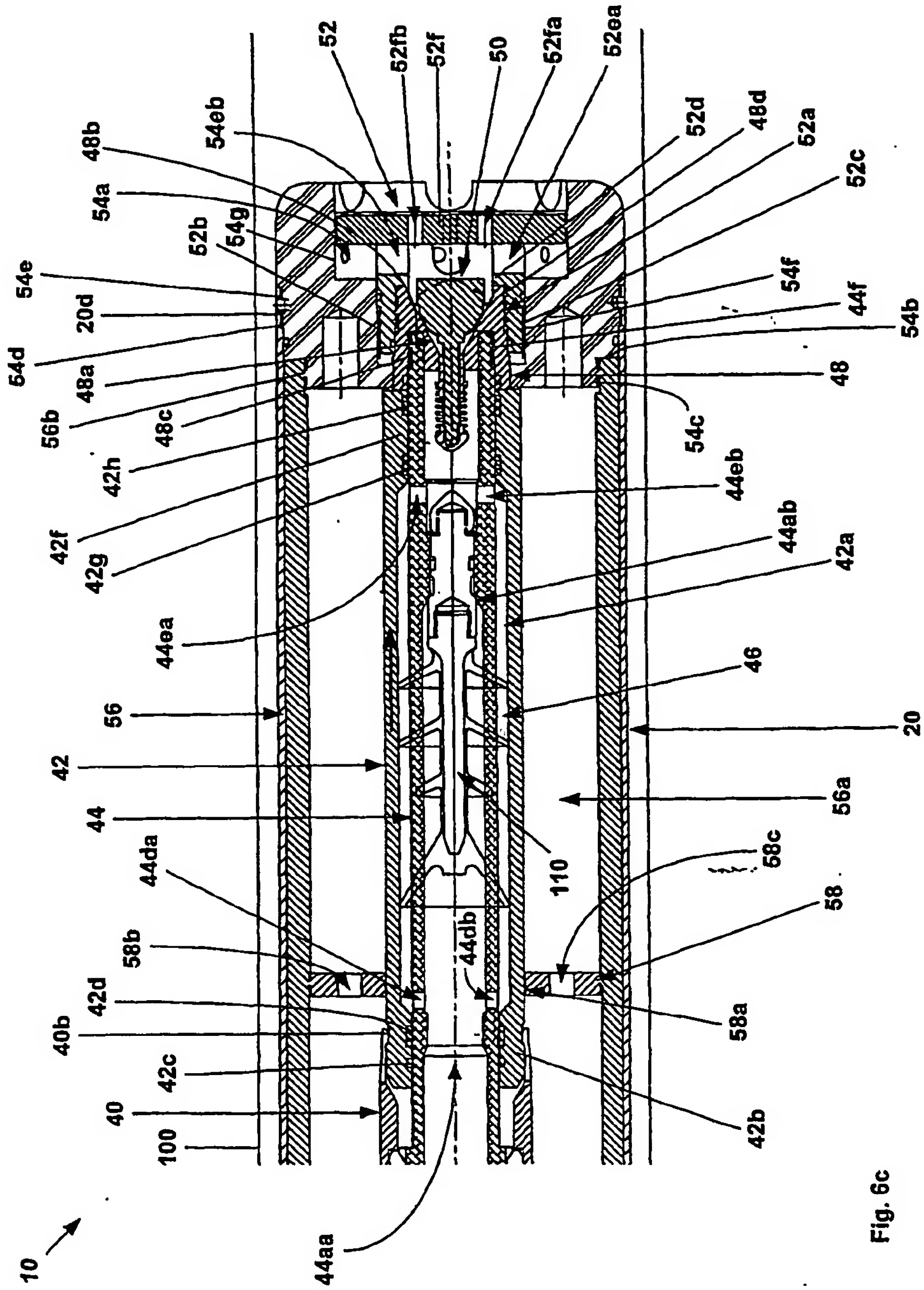
30
10
30a

Fig. 6b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52c
54f
44f
54b
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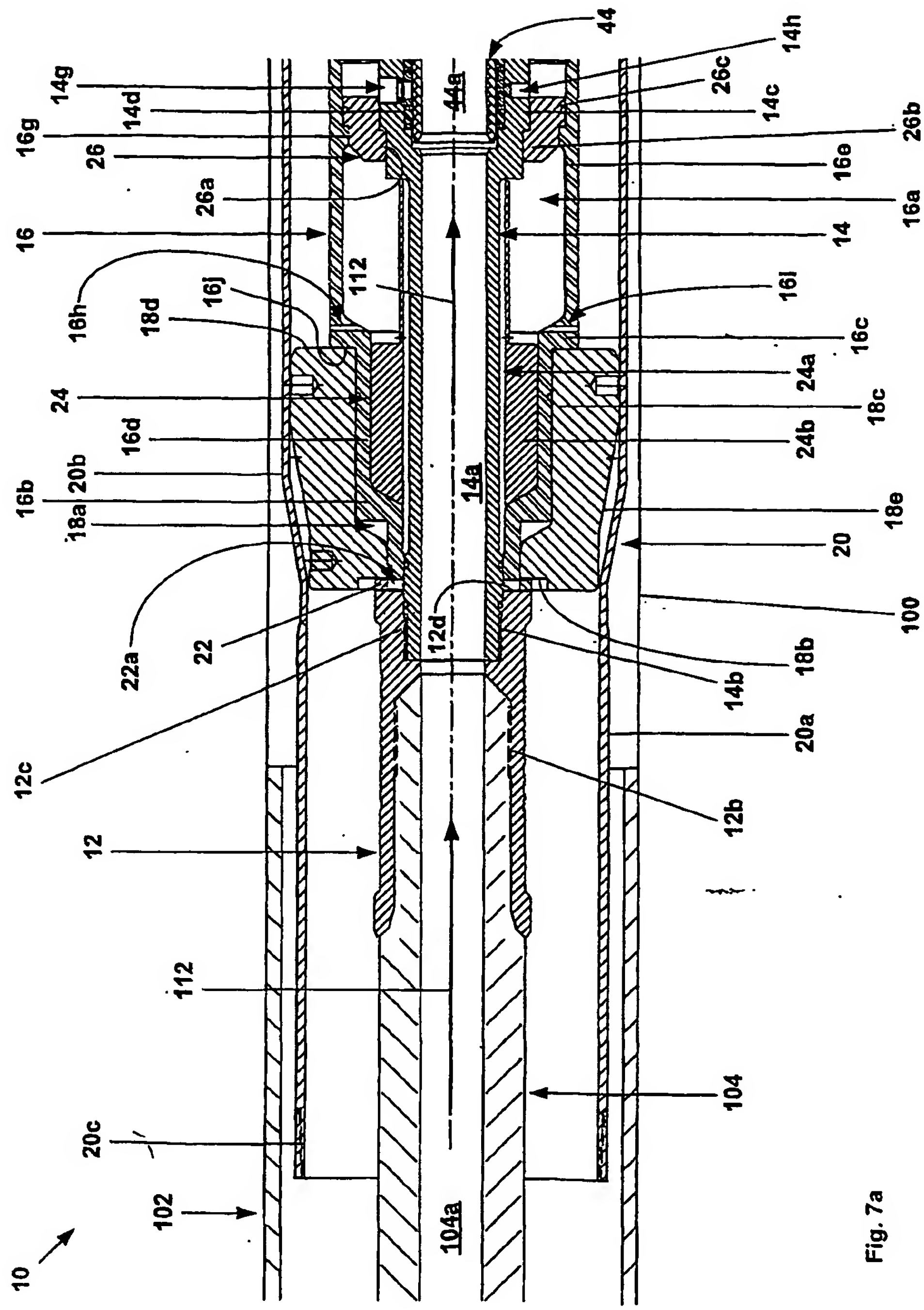
Fig. 6c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14c
26b
16e
16a
14
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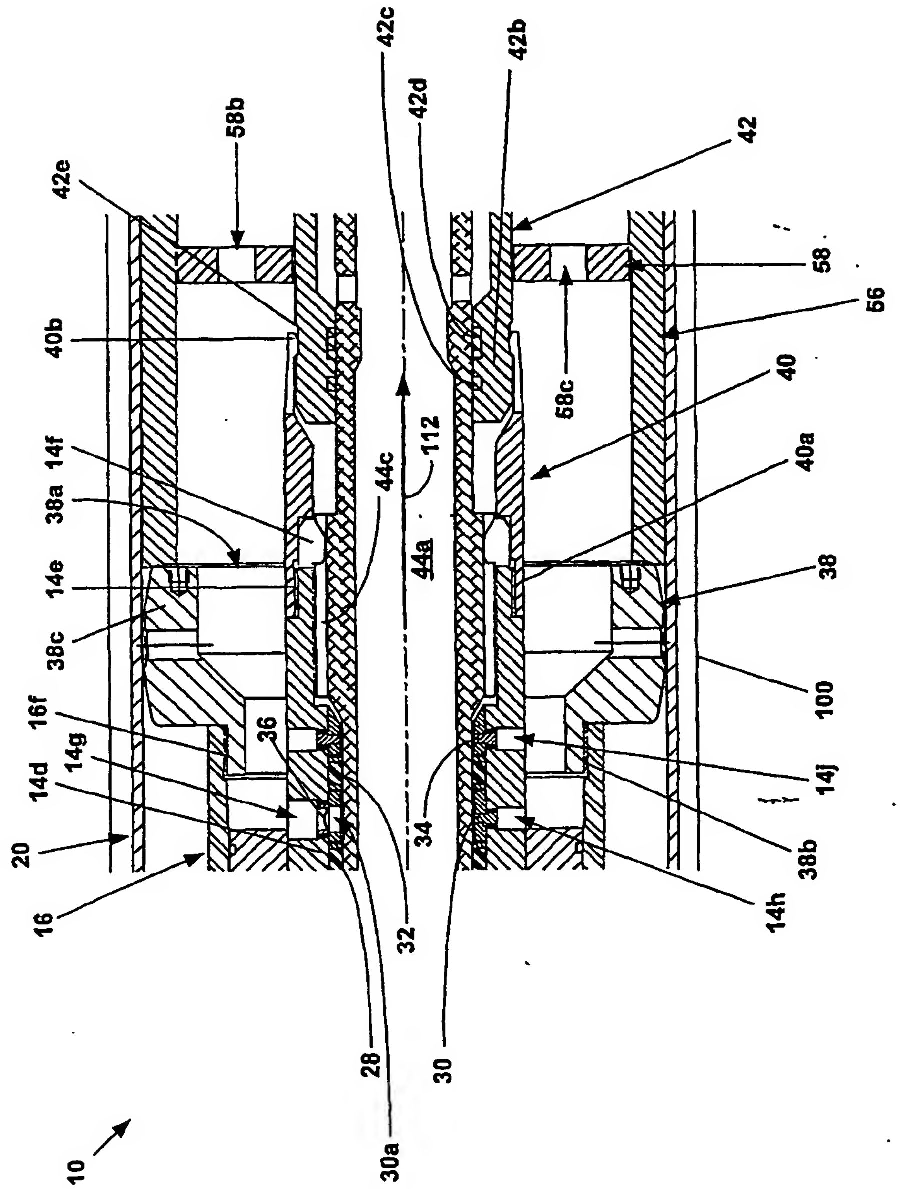
Fig. 7a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44a
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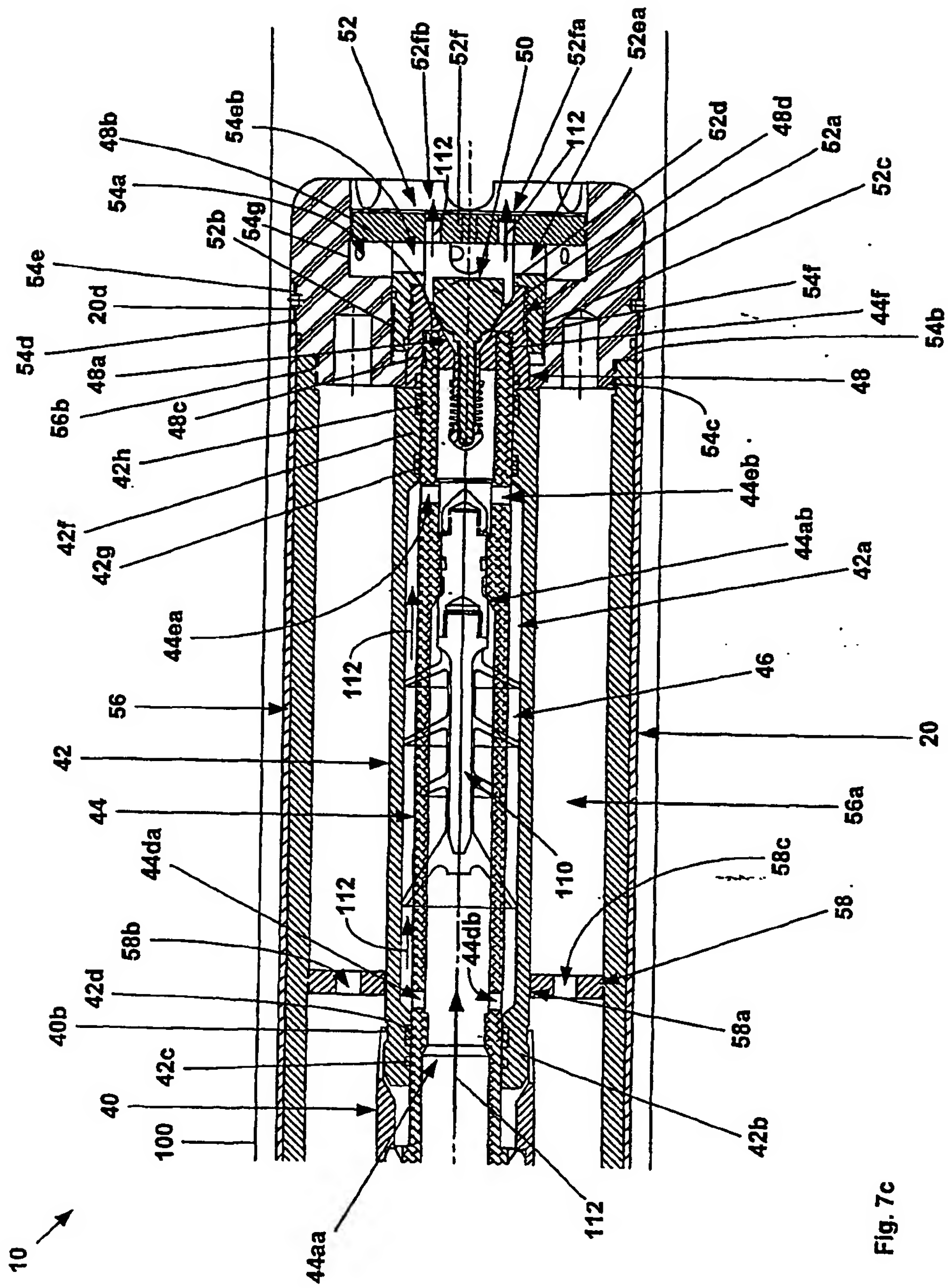
38b
14h

Fig. 7b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44ea
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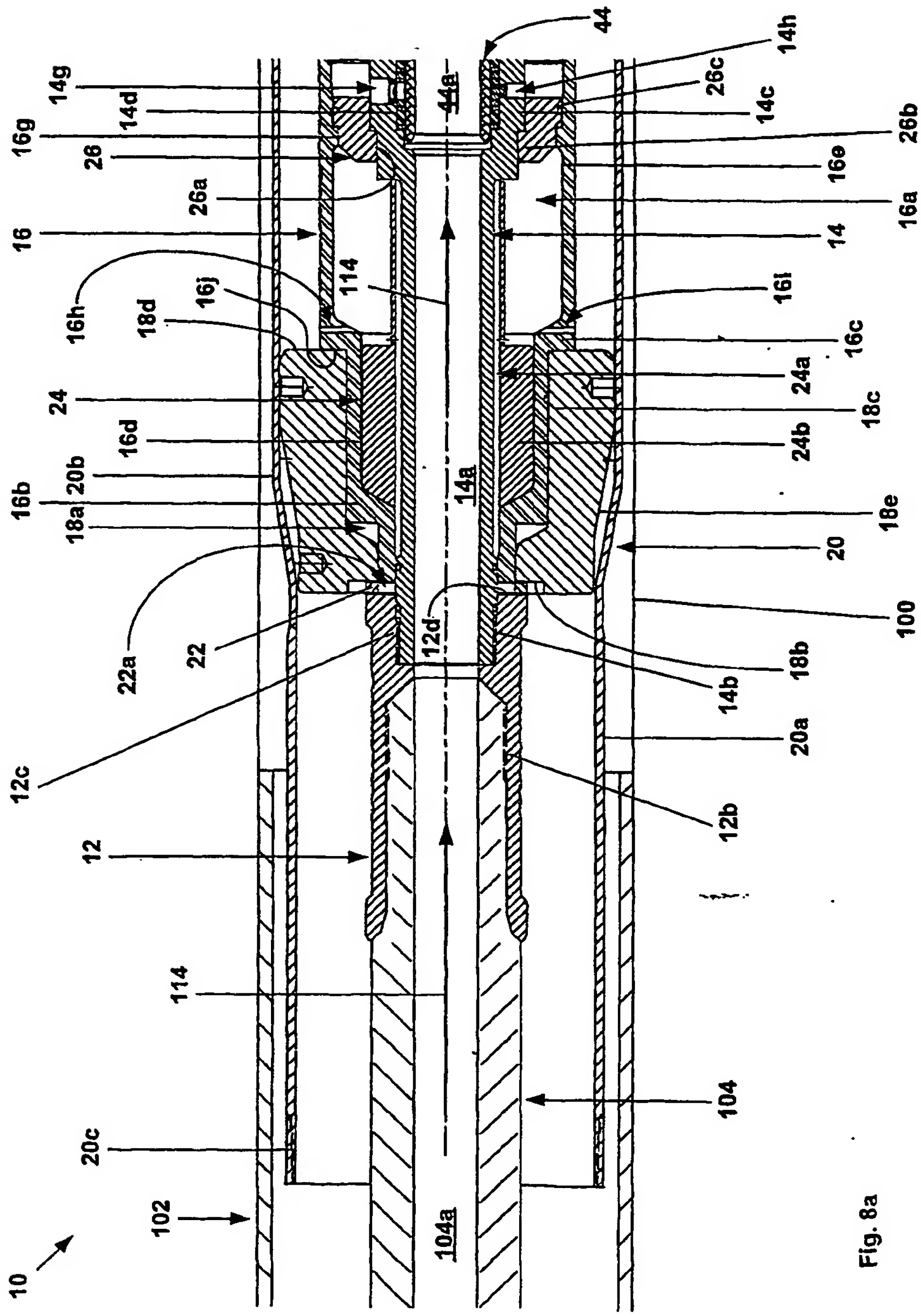
Fig. 7c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16i
18d
16c
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24
18c
16d
24b
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20b
16b
18e
18a
20
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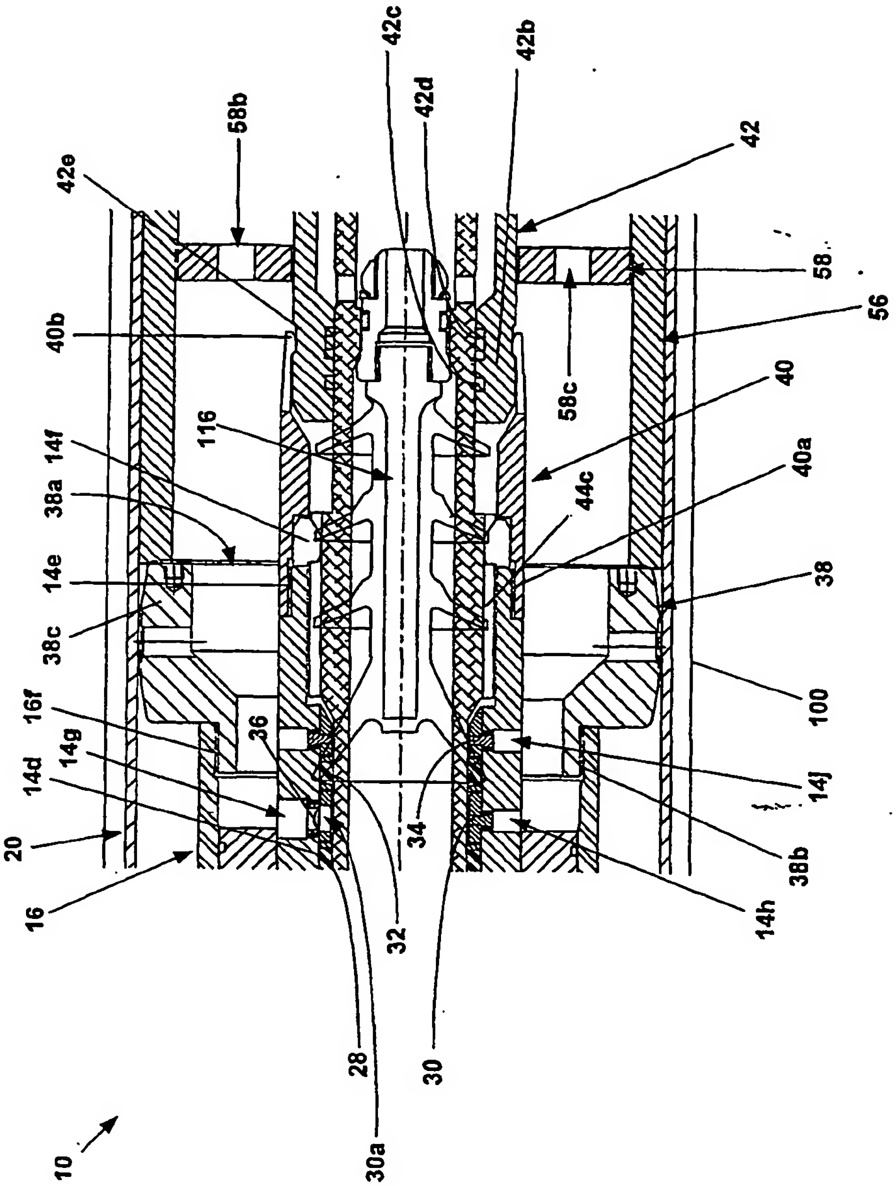
Fig. 8a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38c
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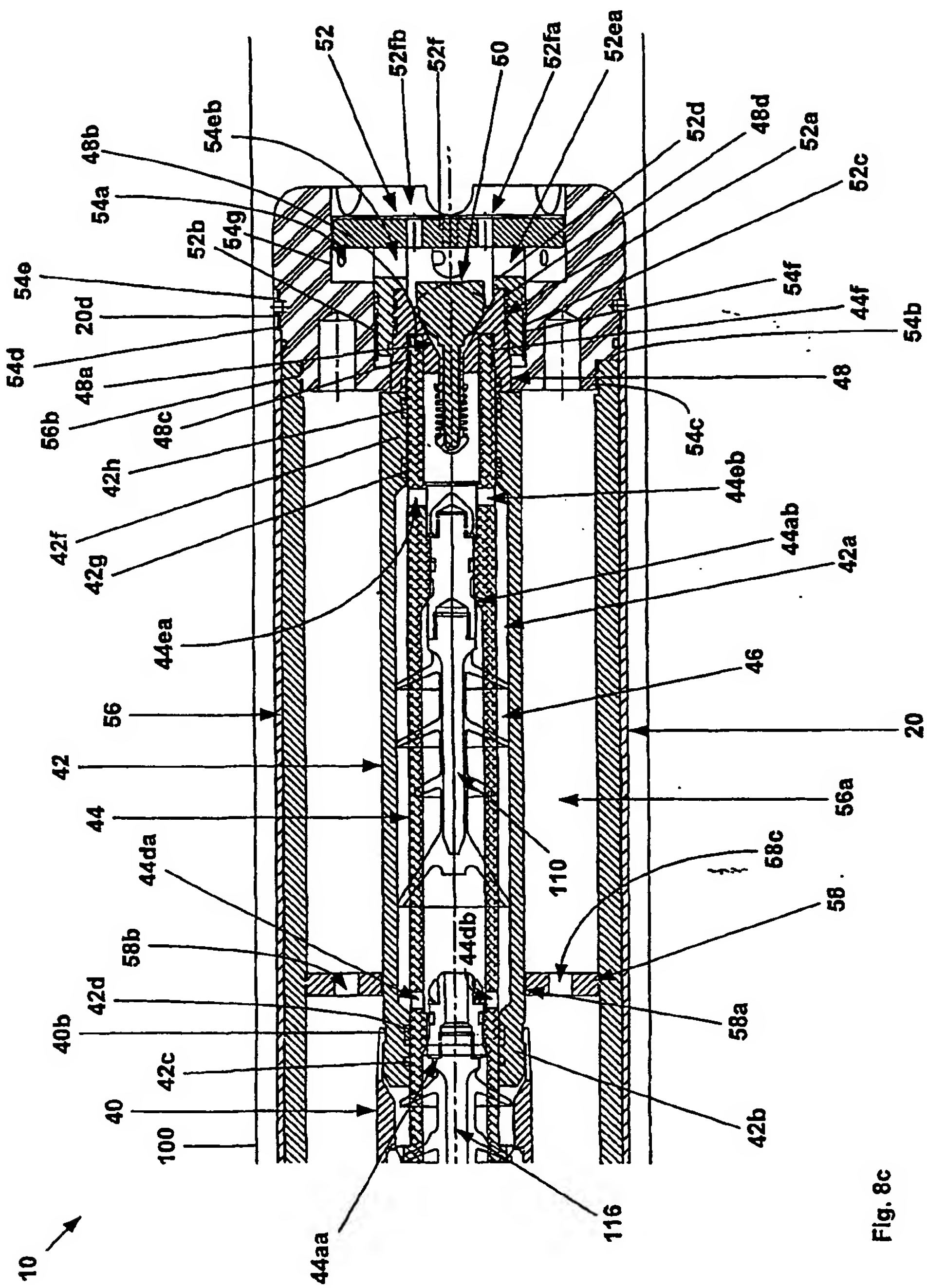
Fig. 8b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52a
52c
54f
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Fig. 8c

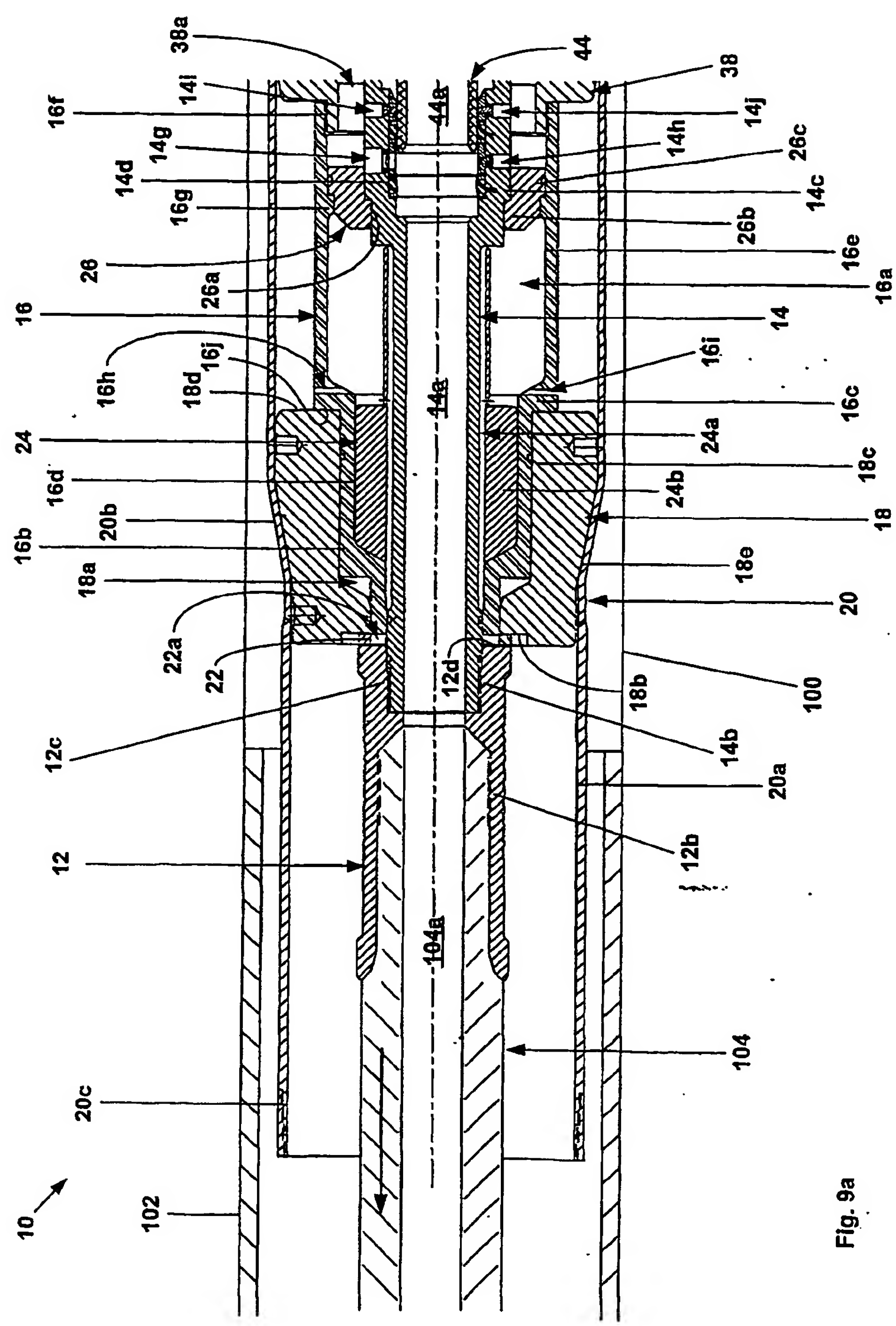
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Fig. 9a

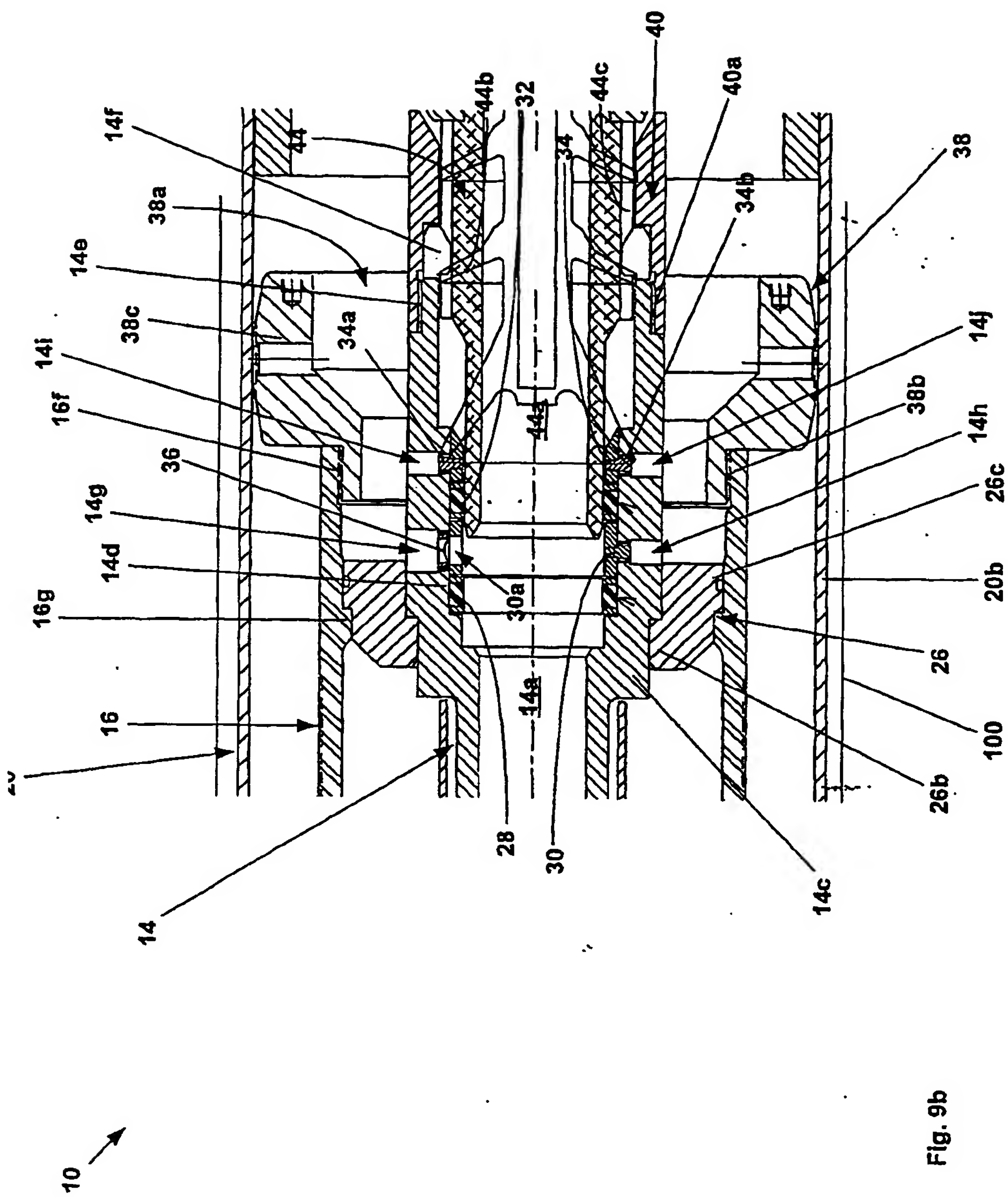
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Fig. 9b

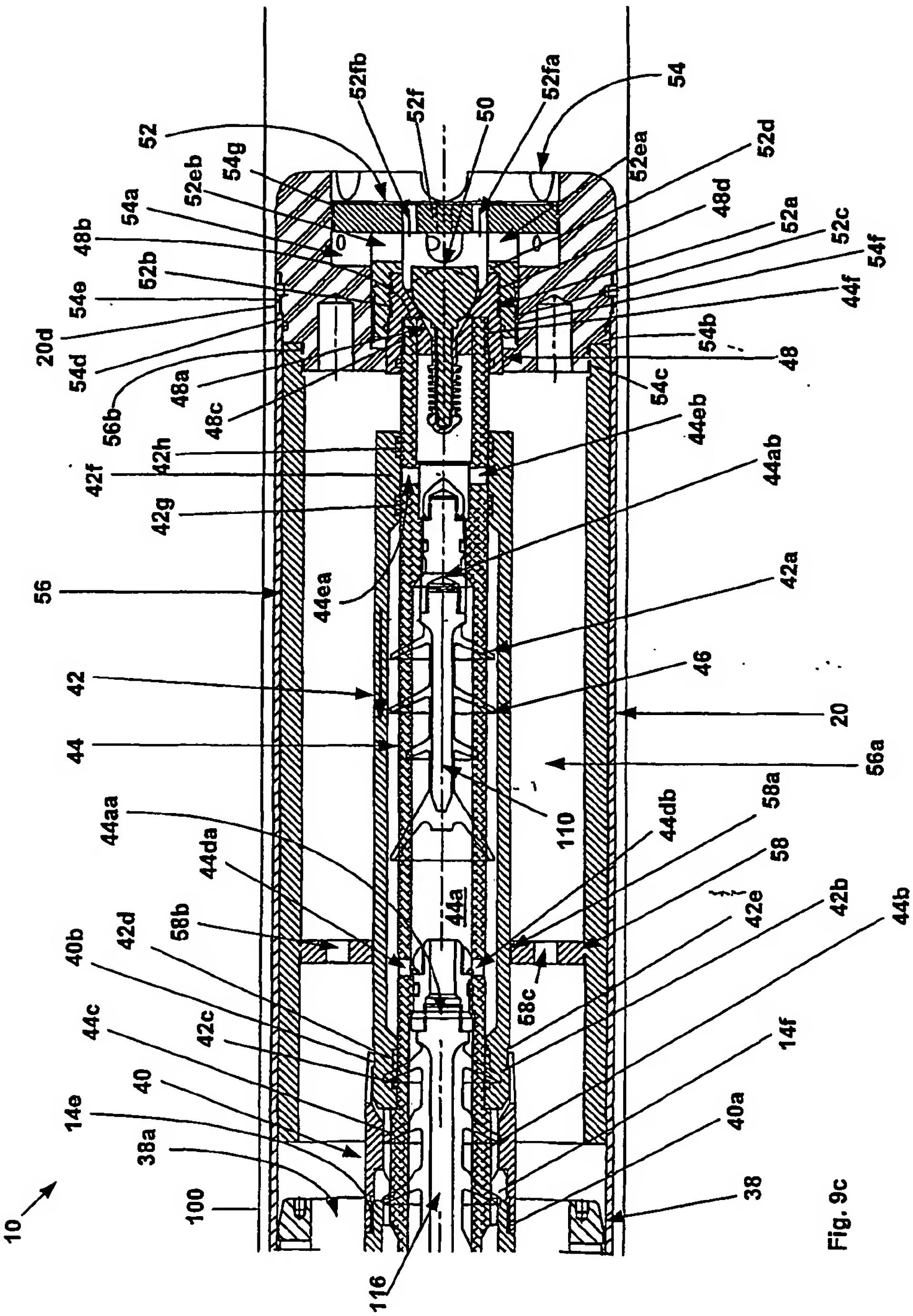
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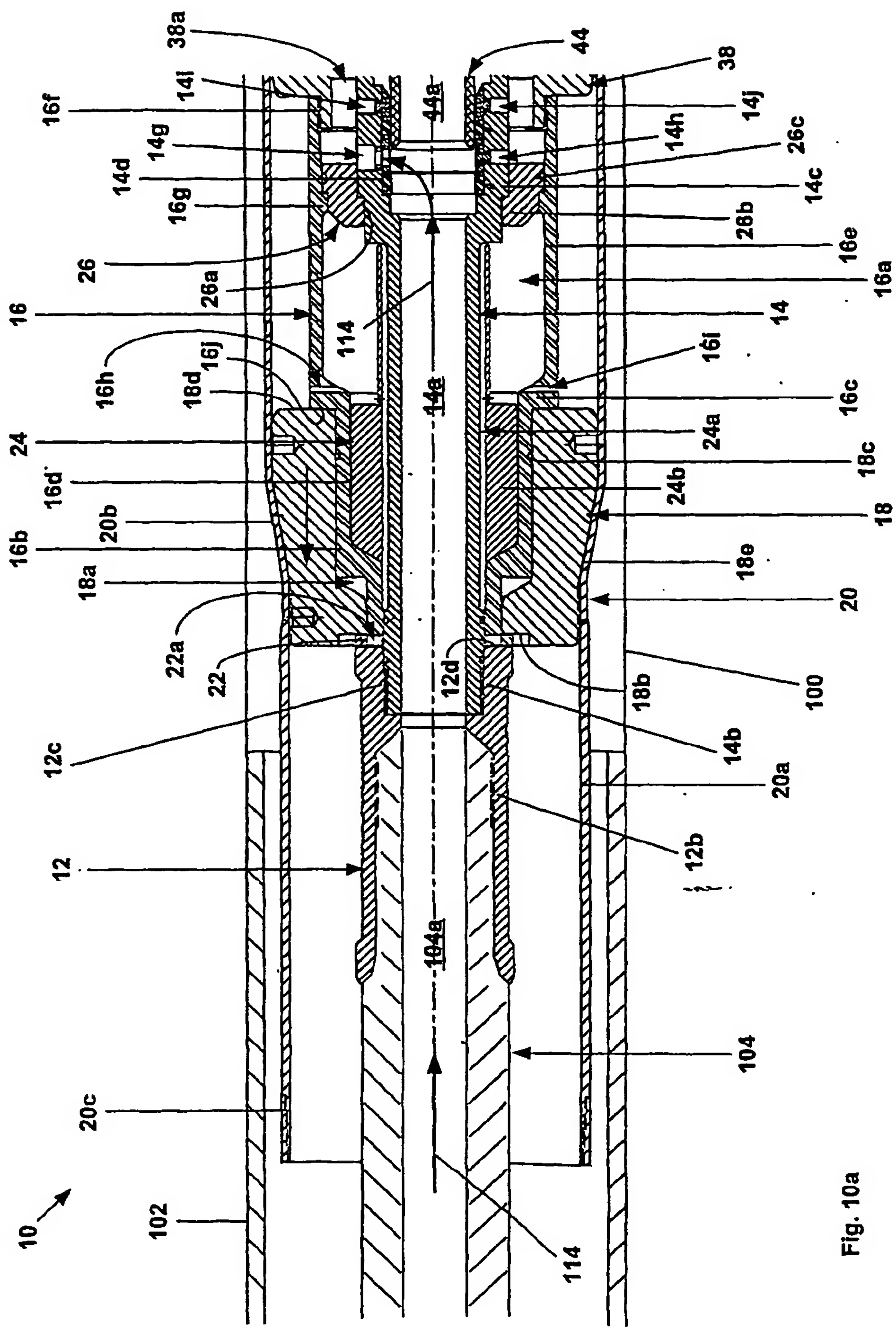
Fig. 9c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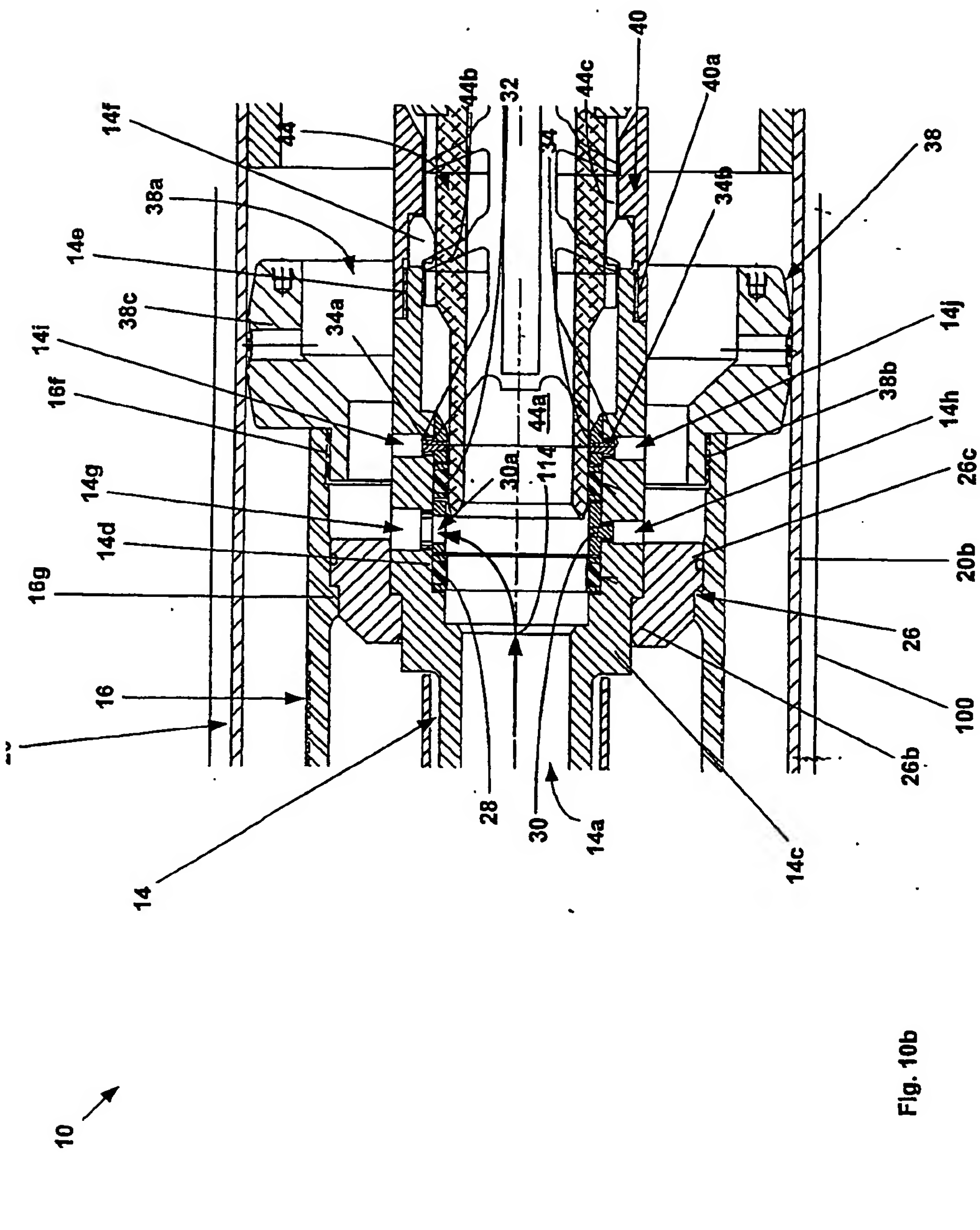
10

Fig. 10a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34b
38
14j
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14a
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Fig. 10b

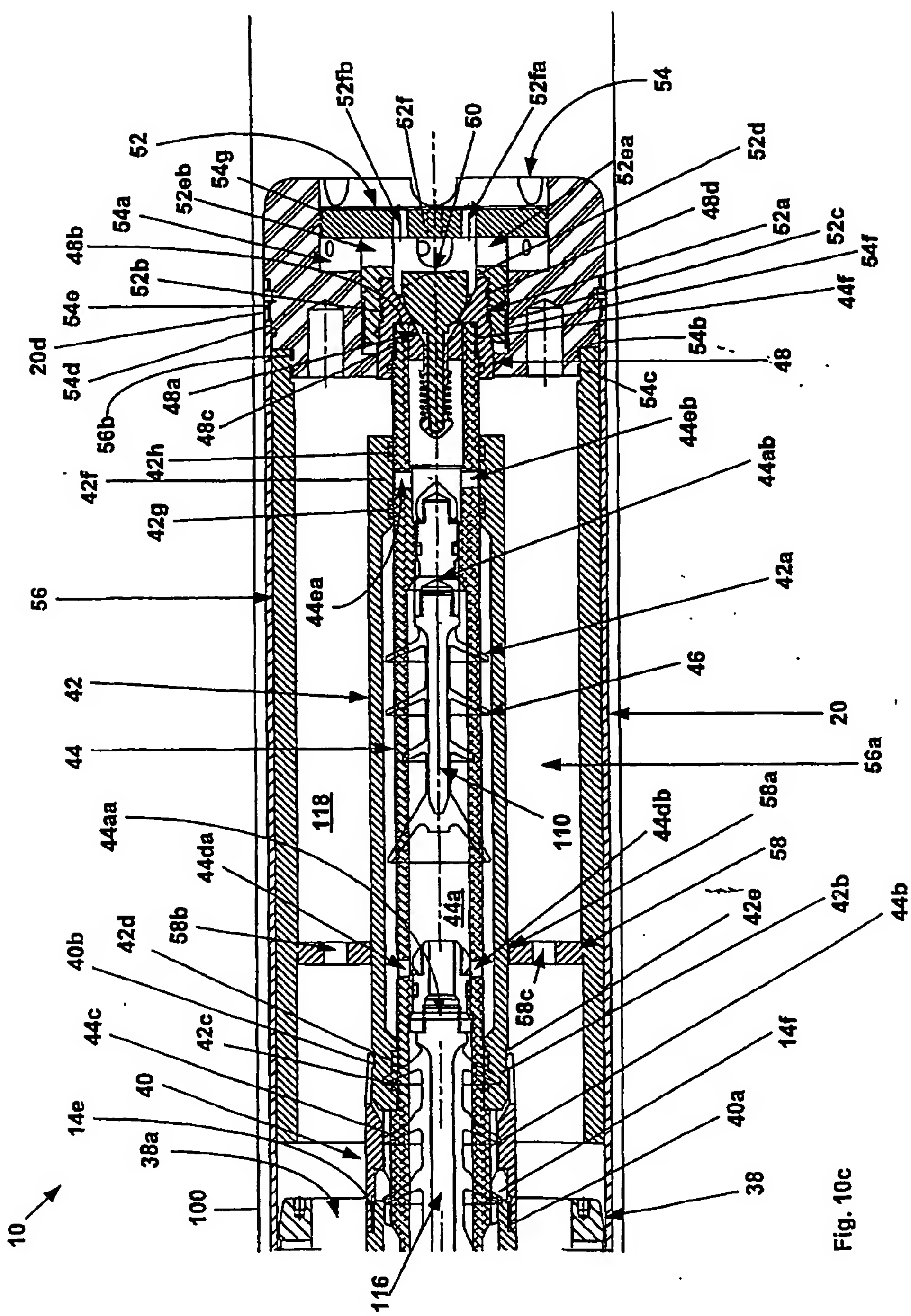
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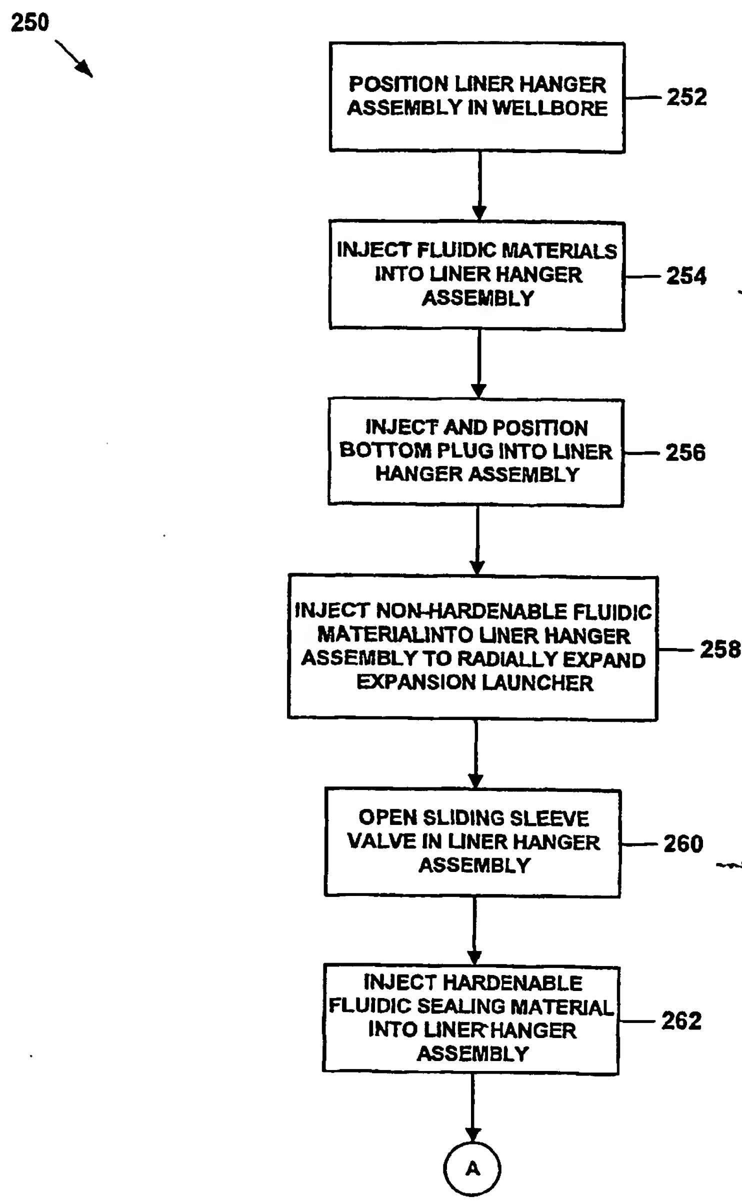
Fig. 10c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INJECT FLUIDIC MATERIALS INTO LINER HANGER ASSEMBLY
254
INJECT AND POSITION BOTTOM PLUG INTO LINER HANGER ASSEMBLY
256
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
258
OPEN SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
260
INJECT HARDENABLE FLUIDIC SEALING MATERIAL INTO LINER HANGER ASSEMBLY
262
A

Fig. 11a

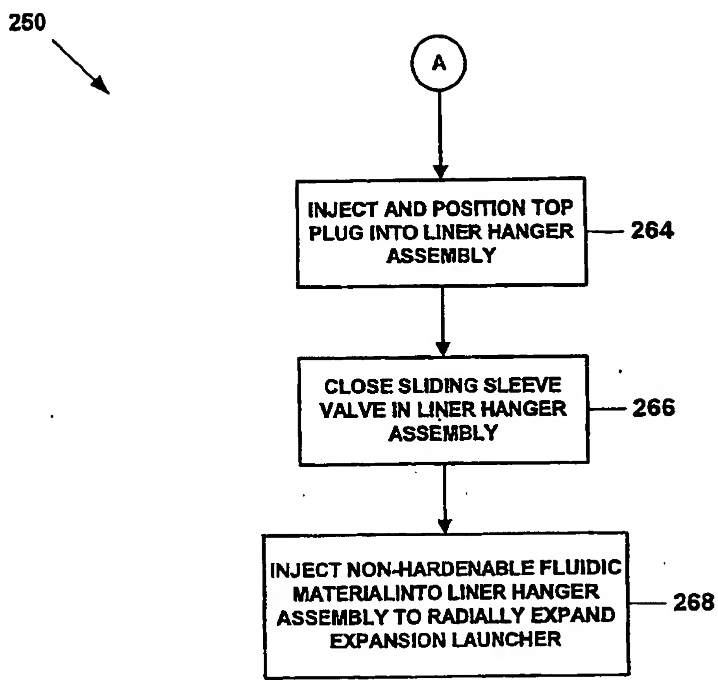
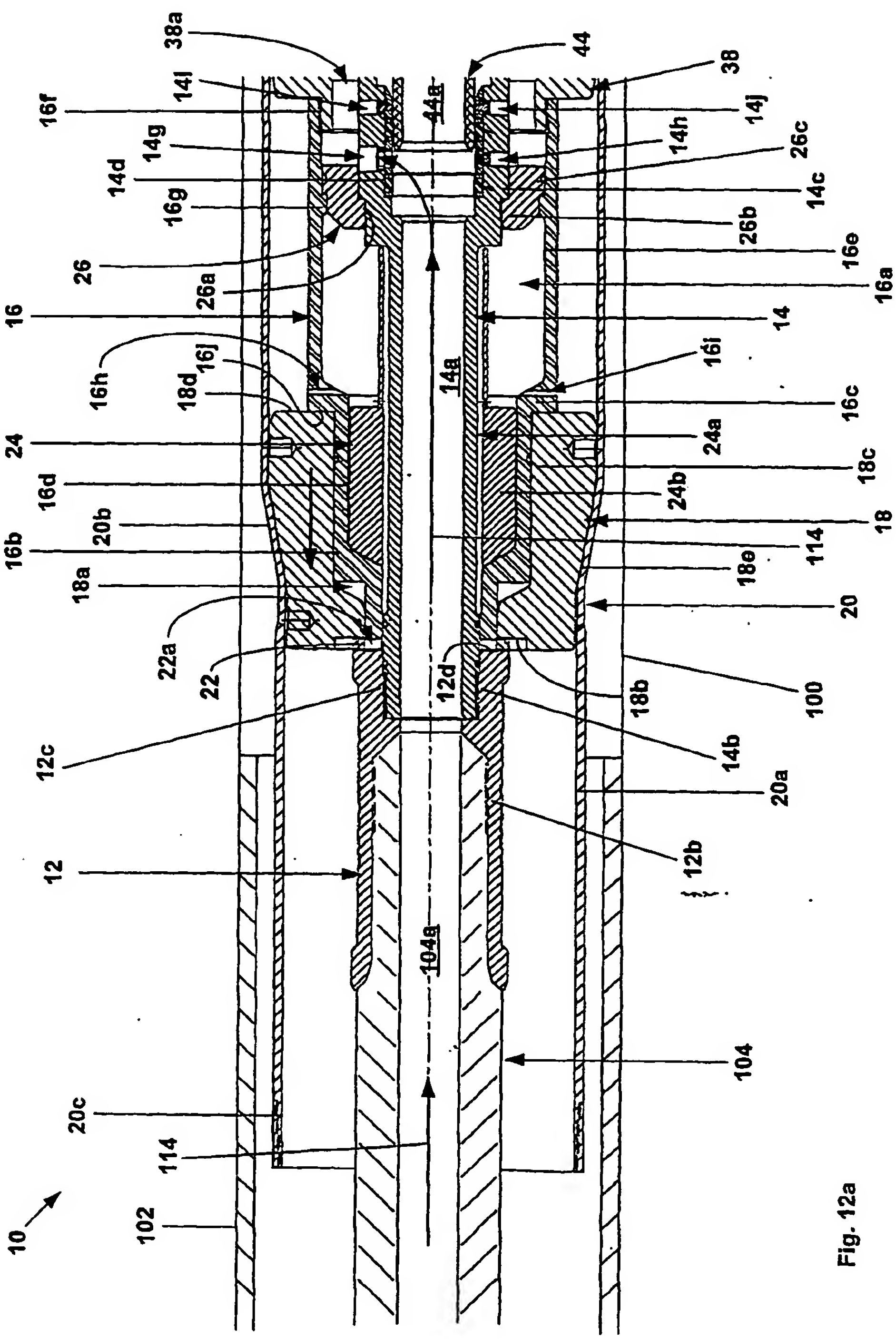

250
A
INJECT AND POSITION TOP PLUG INTO LINER HANGER ASSEMBLY
264
CLOSE SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
266
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
268

Fig. 11b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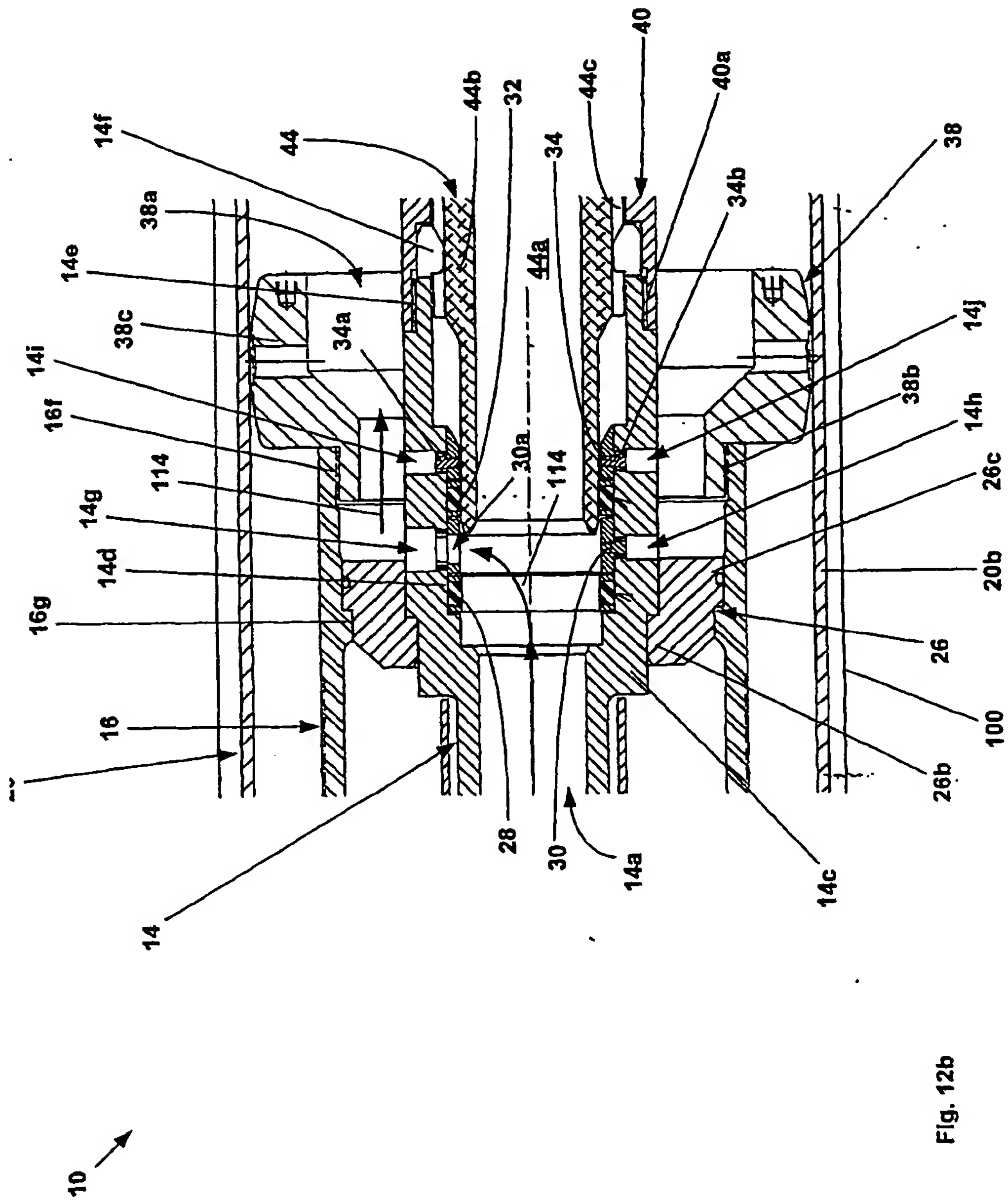
14
14a
16h
16j
18d
16i
16c
24
24a
18c
16d
24b
20b
18
16b
114
18e
18a
20
22a
22
12d
18b
100
12c
14b
20a
12
12b
104a
104
20c
114
10
102

Fig. 12a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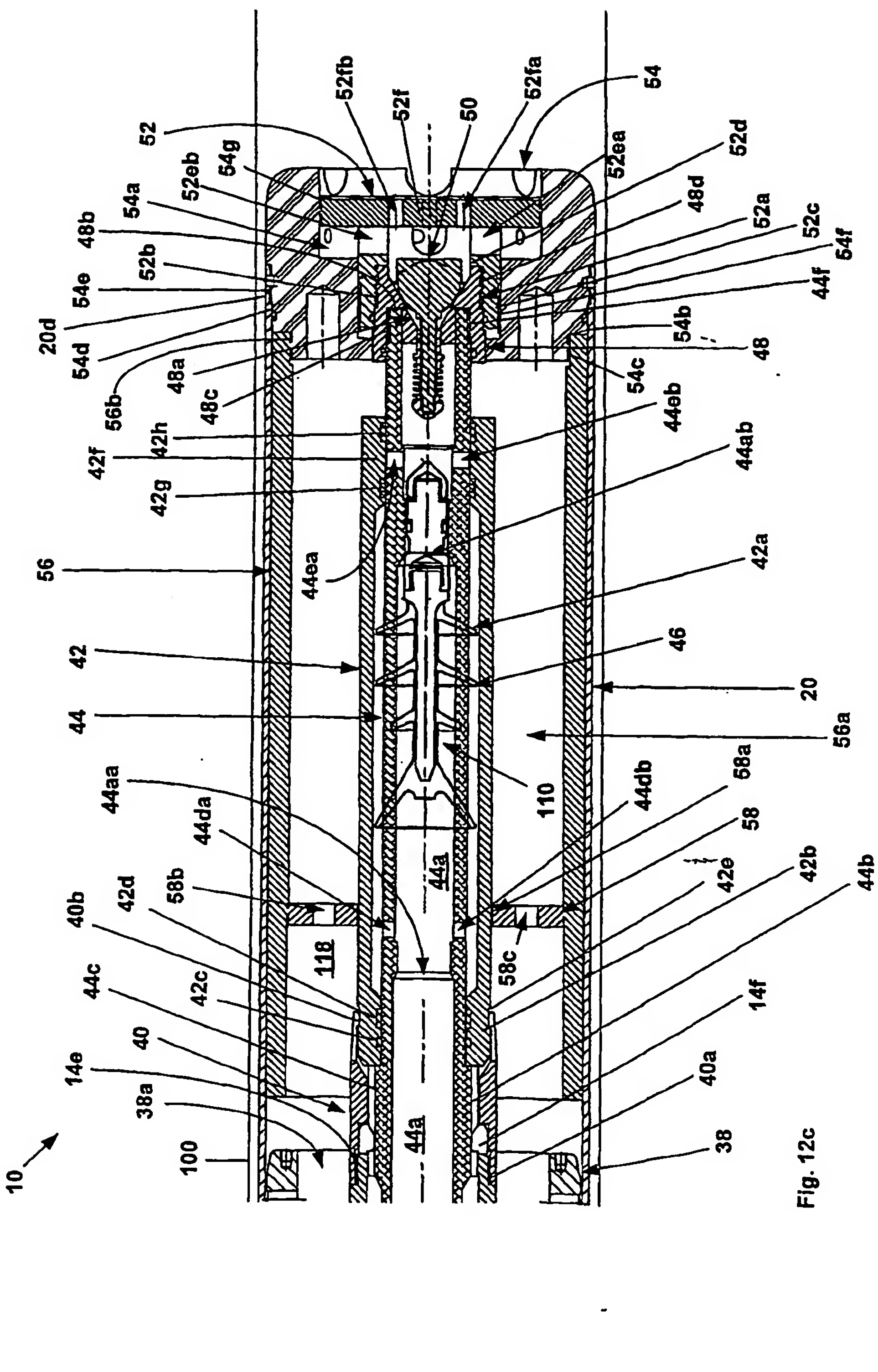
14e
44a
34b
38
38c
34a
14i
16f
114
30a
114
38b
14h
14j
14g
14d
16g
26c
20b
26
16
100
26b
14
28
30
14a
14c
10

Fig. 12b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52d
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48d
52a
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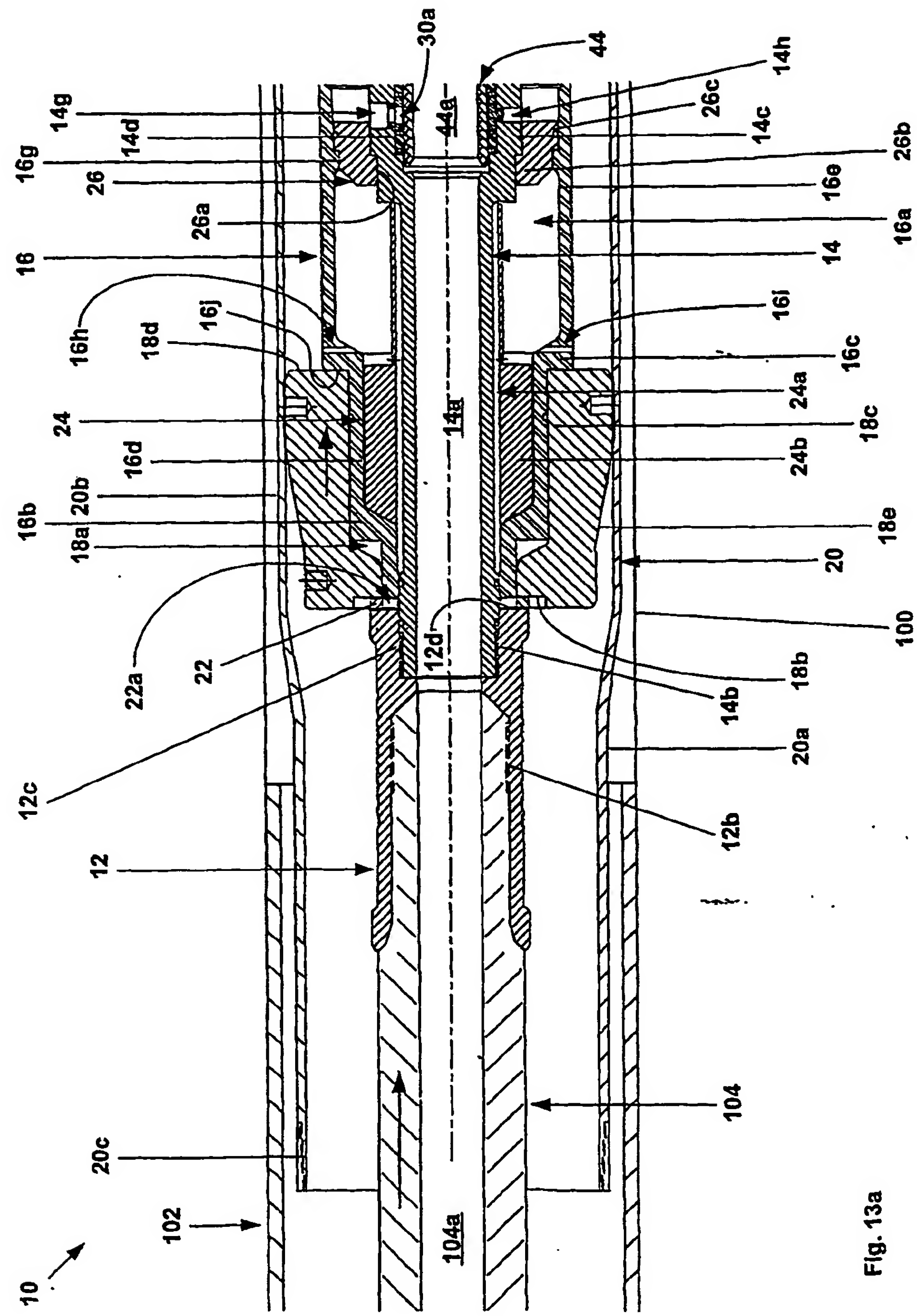
52b
54e
44f
20d
54b
54d
48
56b
48a
48c
54c
44eb
42h
42f
42g
44ab
56
44ea
42a
42
46
44
20
56a
44aa
110
44da
44db
58a
58b
58
42d
40b
118
44a
42e
58c
42b
44c
42c
14f
44b
40
14e
40a
38a
100
38
10

Fig. 12c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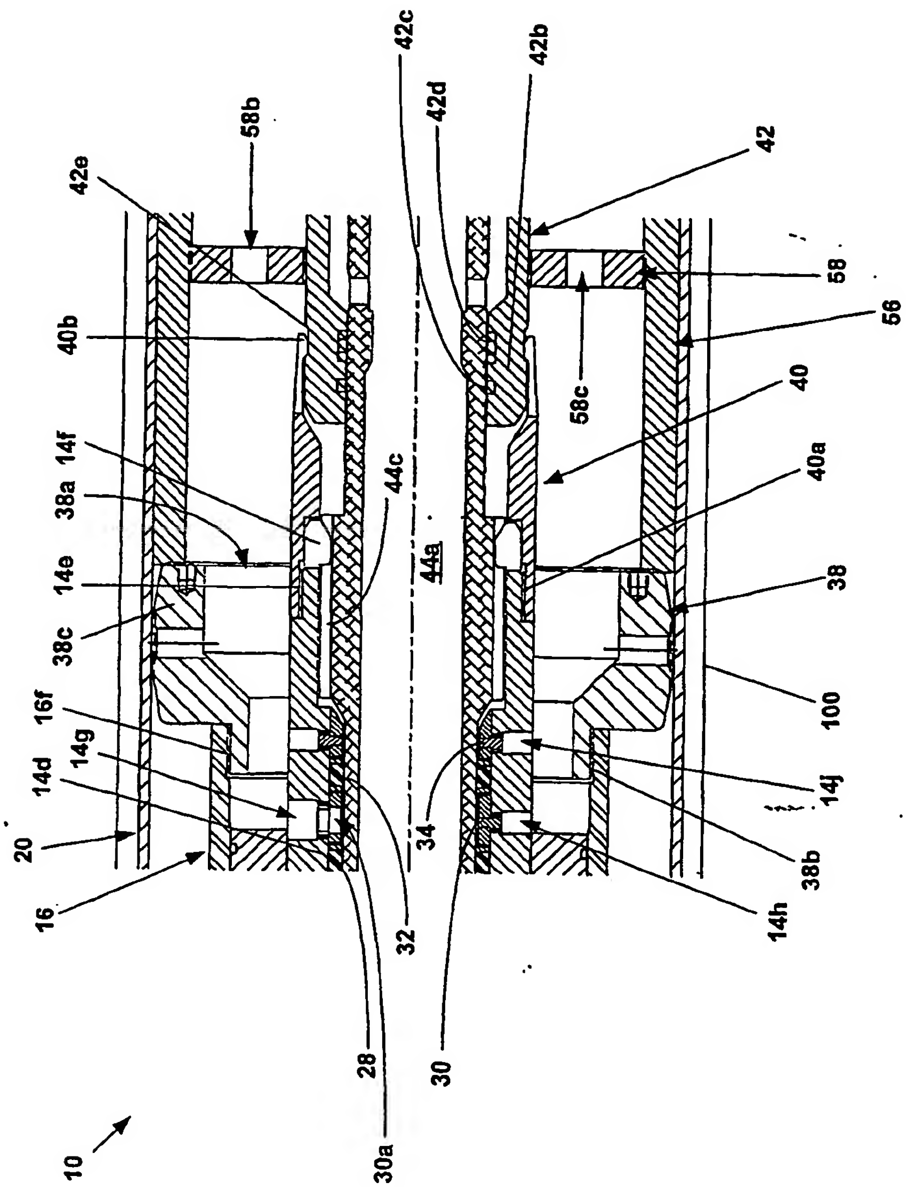
44
14h
14g
14d
16g
26
26a
16
16h
18d
16j
24
16d
20b
16b
18a
22a
22
12c
12
20c
102
10
26c
14c
26b
16e
16a
14
16i
16c
24a
18c
24b
18e
20
100
18b
14b
20a
12b
104
44a
14a
12d
104a

Fig. 13a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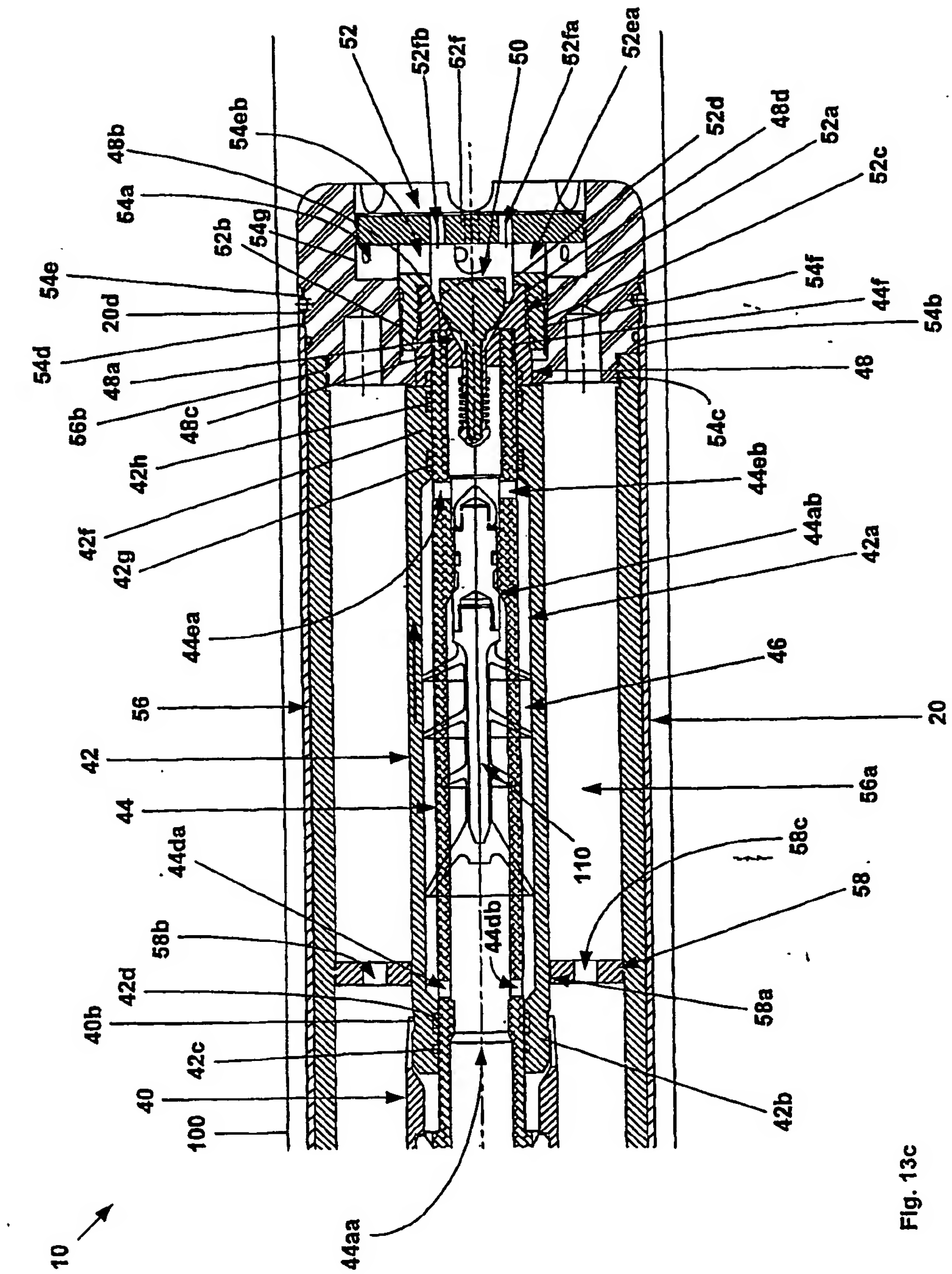
16
20
14d
14g
16f
38c
14e
38a
14f
40b
42e
58b
28
30a
32
44c
44a
34
30
42c
42d
42b
42
58
56
58c
40
40a
38
100
14j
38b
14h

Fig. 13b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44aa
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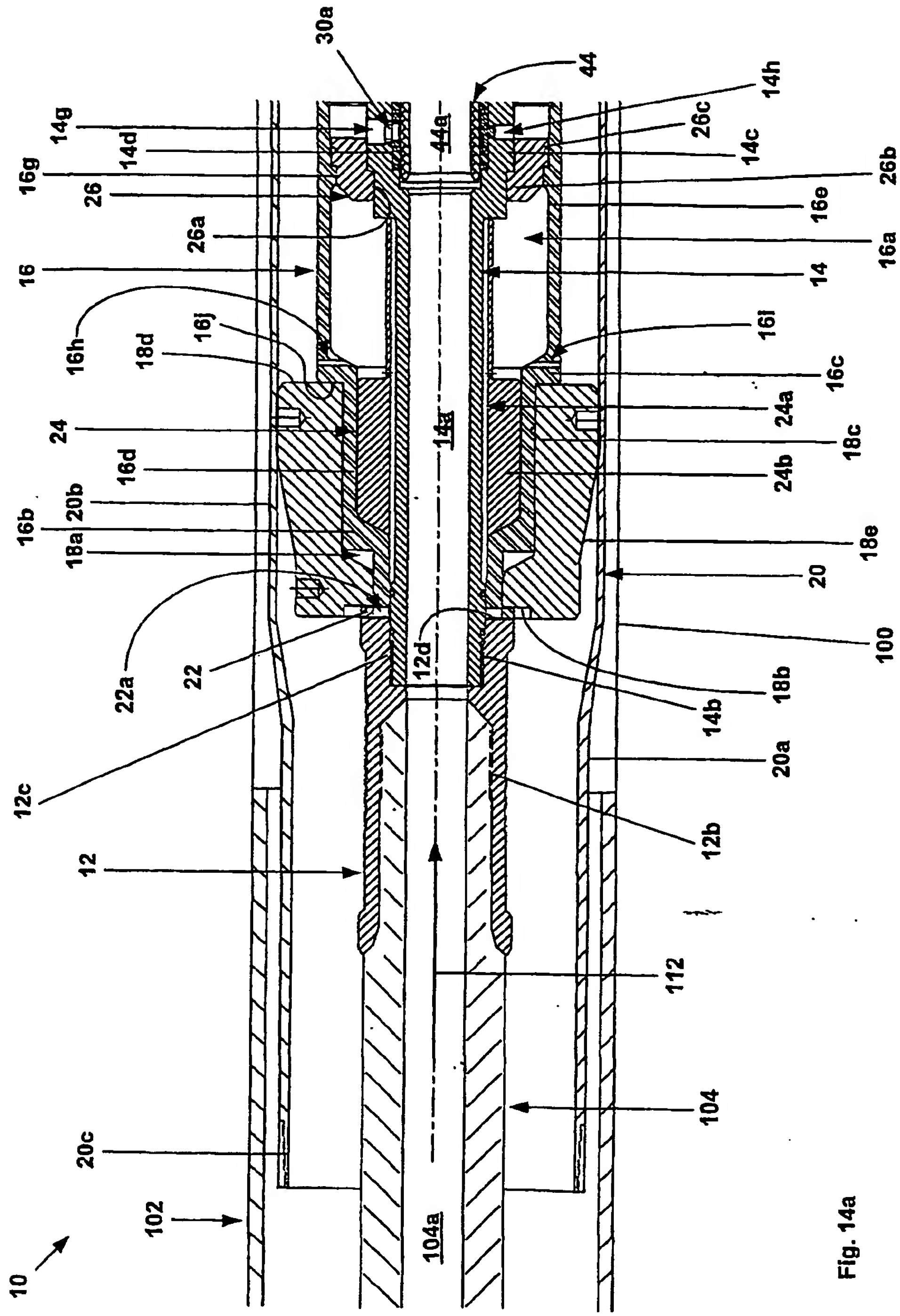
40
42c
40b
42d
58b
44da
44
42
56
44ea
42g
42f
42h
48c
56b
48a
54d
20d
54e
52b
54g
54a
48b
54eb
52
52fb
52f
50
52fa
52ea
52d
48d
52a
52c
54f
44f
54b
48
54c
44eb
44ab
42a
46
20
56a
110
58c
58
44db
58a
42b

Fig. 13c


10
102
20c
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12c
22a
22
18a
16b
20b
16d
24
18d
16h
16j
16
26a
26
16g
14d
14g
30a
44
44a
14h
26c
14c
26b
16e
16a
14
16i
16c
24a
14a
18c
24b
18e
20
100
18b
12d
14b
20a
12b
112
104
104a

Fig. 14a

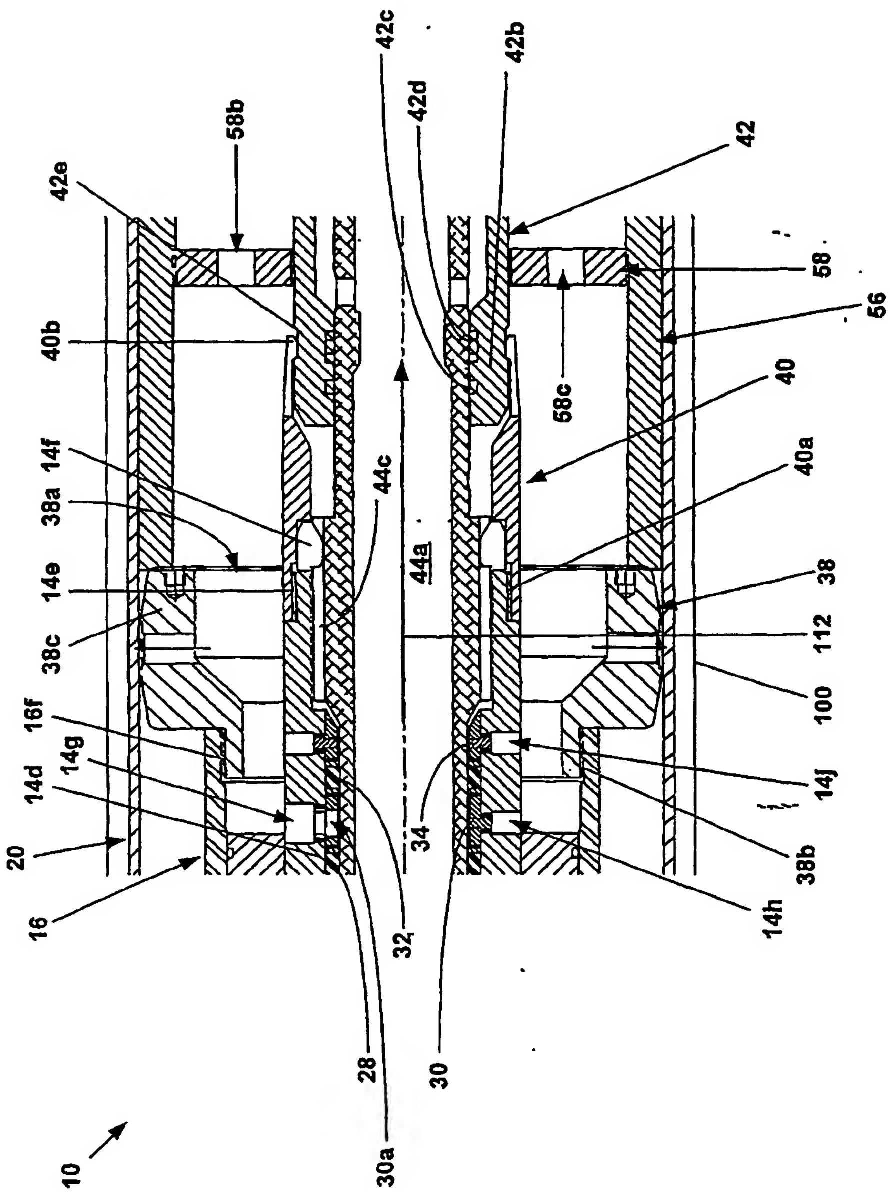
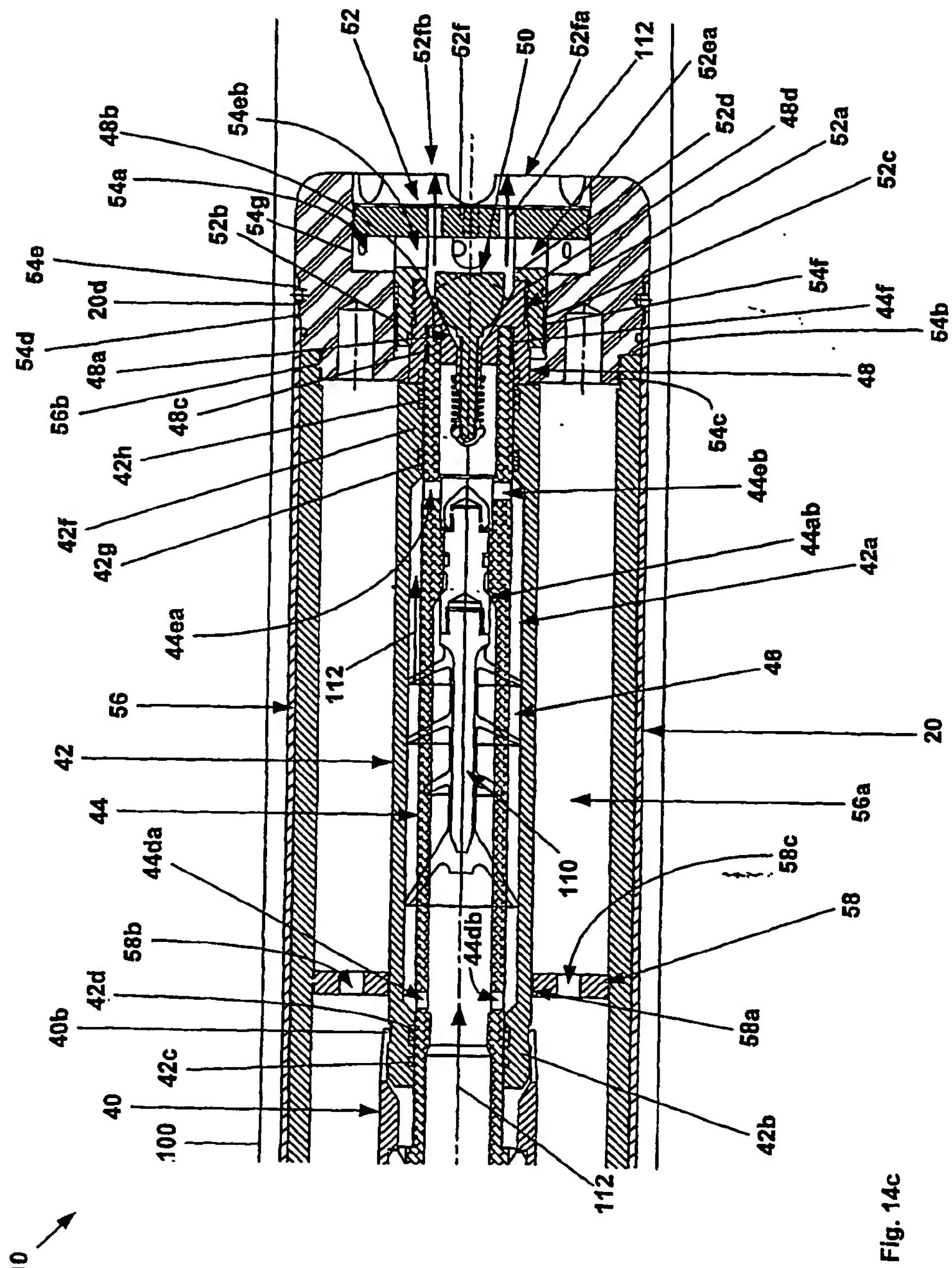

42c
42b
42d
58b
42e
42
58
56
40b
58c
40
14f
38a
44c
40a
44a
14e
38
38c
112
16f
100
14g
14d
34
14j
20
38b
16
14h
32
28
30
10
30a

Fig. 14b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52fa
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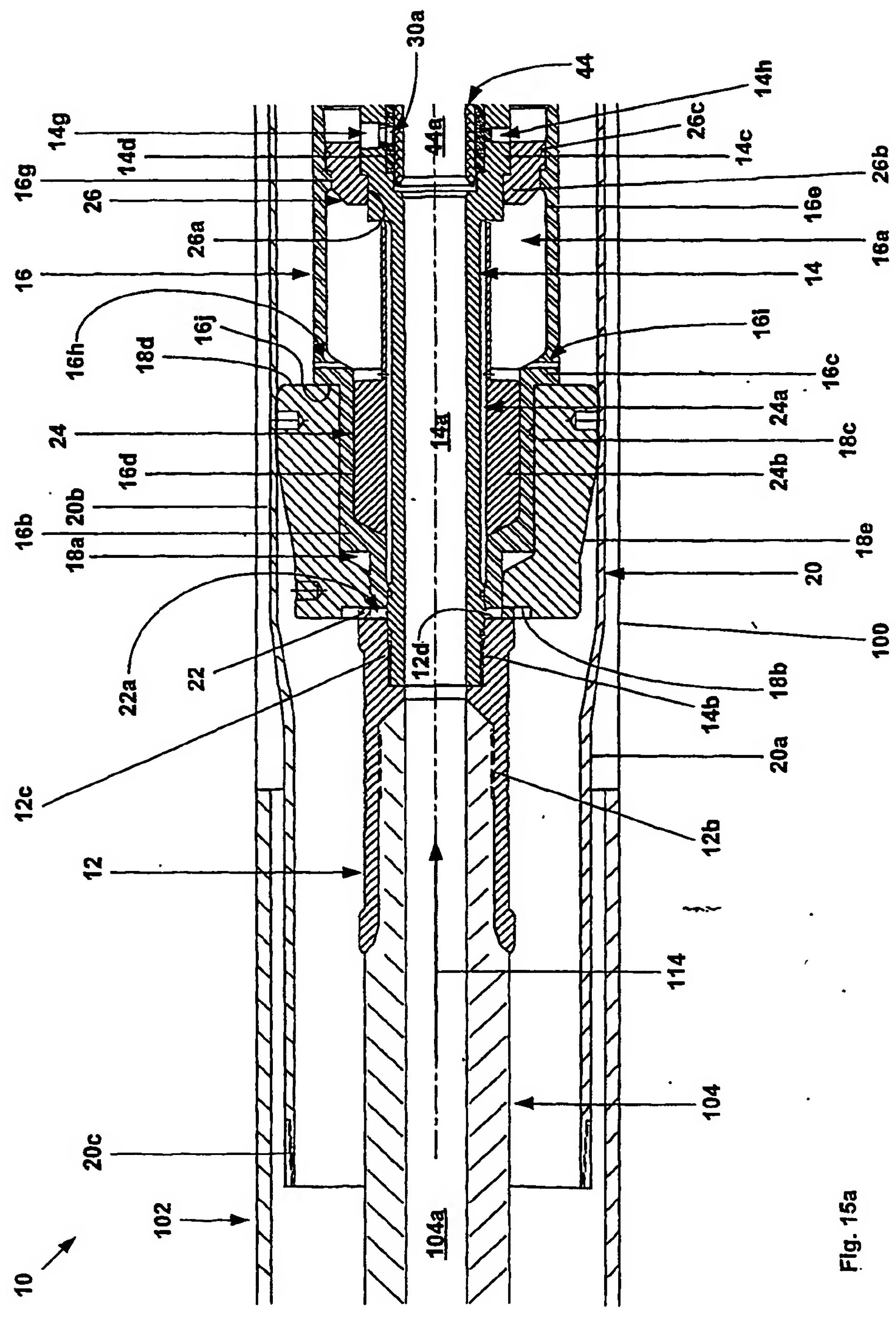
52ea
54eb
52d
48b
48d
52a
54a
52c
52b
54g
54e
54f
20d
44f
54d
54b
48a
48
56b
48c
54c
42h
42f
44eb
42g
44ab
42a
44ea
112
48
56
20
42
44
56a
44da
110
58c
58b
58
44db
42d
40b
58a
42c
42b
40
100
112
10

Fig. 14c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14g
44a
26c
14d
14c
16g
26b
26
16e
26a
16a
16
14
16h
16j
16i
18d
16c
24
14a
24a
18c
16d
24b
20b
16b
18e
18a
20
22a
22
12d
100
18b
14b
12c
20a
12b
12
114
104
20c
102
104a
10

Fig. 15a

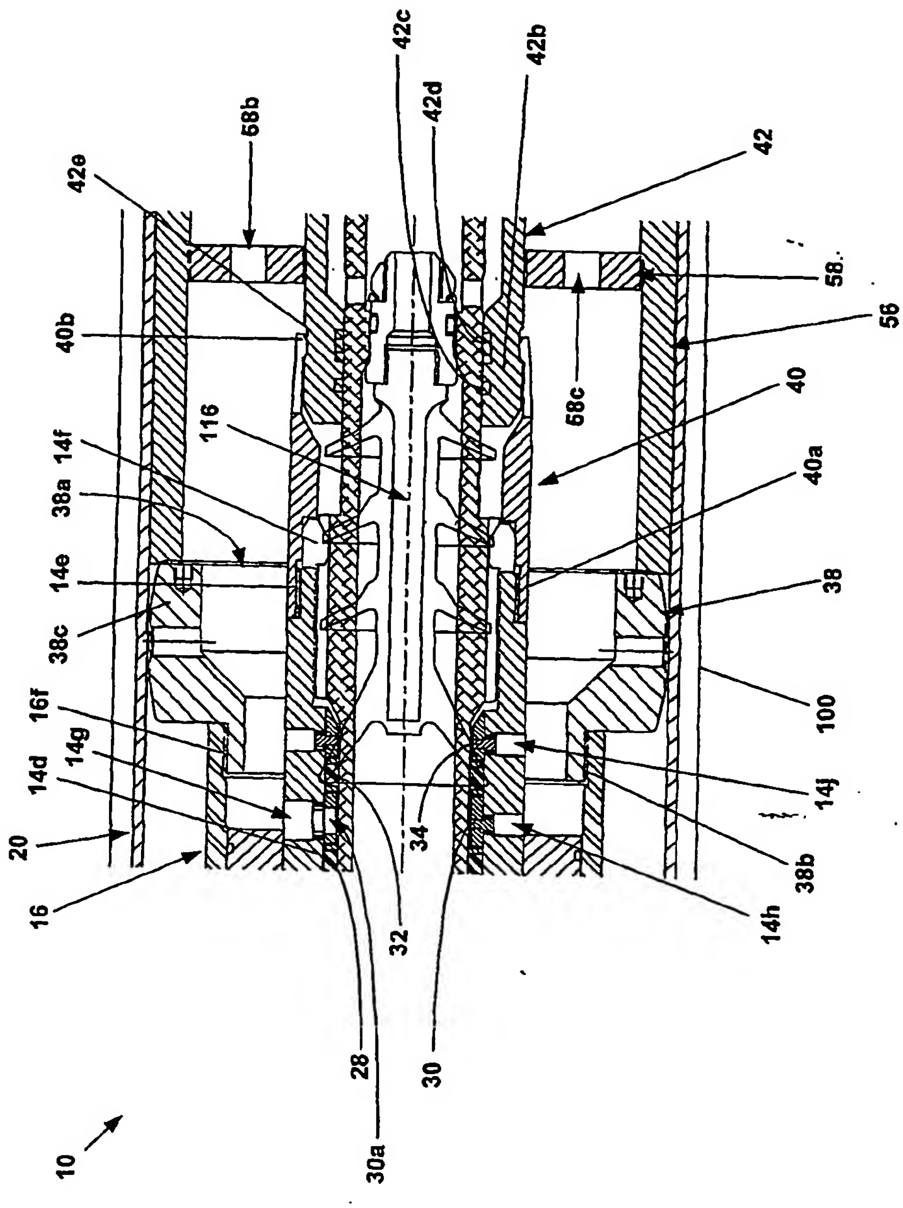
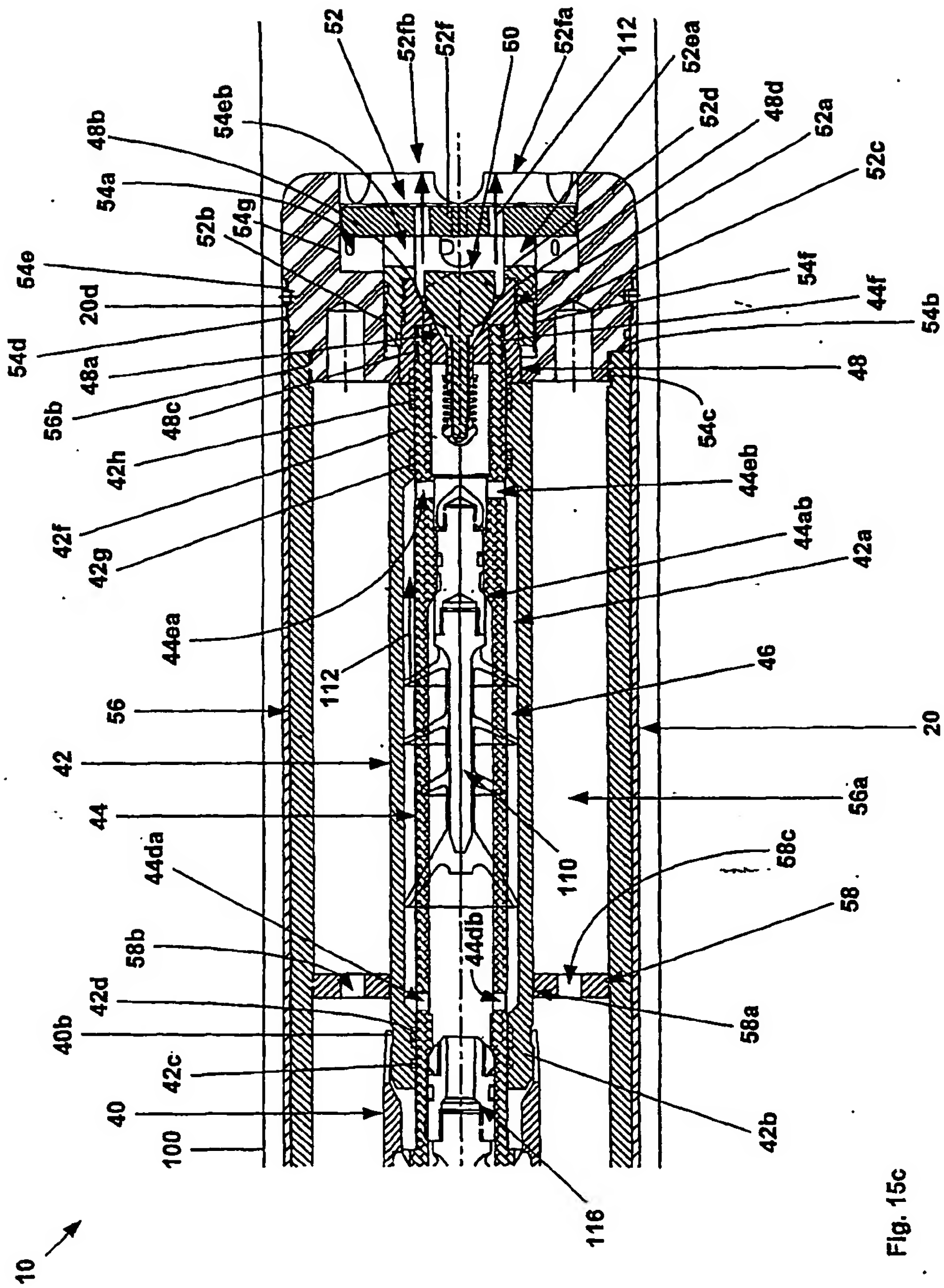

42c
42b
42d
58b
42
42e
58
56
40b
58c
40
116
14f
38a
40a
14e
38
38c
100
16f
14g
14d
14j
20
34
38b
16
32
14h
28
30
10
30a

Fig. 15b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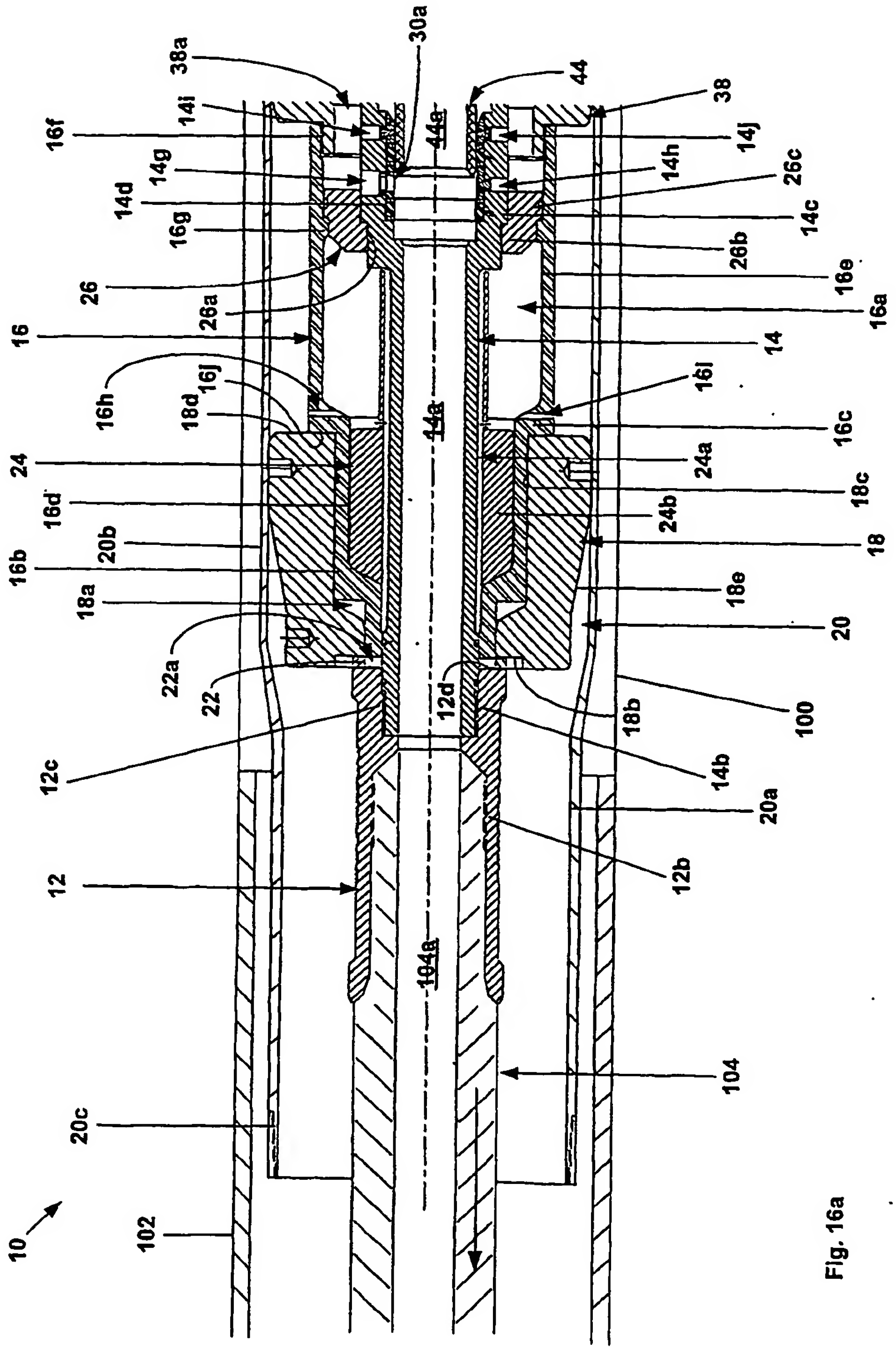
40b
42c
42d
58b
44da
44
42
56
44ea
42g
42f
42h
56b
48a
54d
48c
20d
54e
52b
64g
54a
48b
54eb
52
52fb
52f
50
52fa
112
52ea
52d
48d
52a
52c
54f
44f
54b
48
54c
44eb
44ab
42a
46
112
20
56a
110
58c
58
44db
58a
42b
116

Fig. 15c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38
14i
44a
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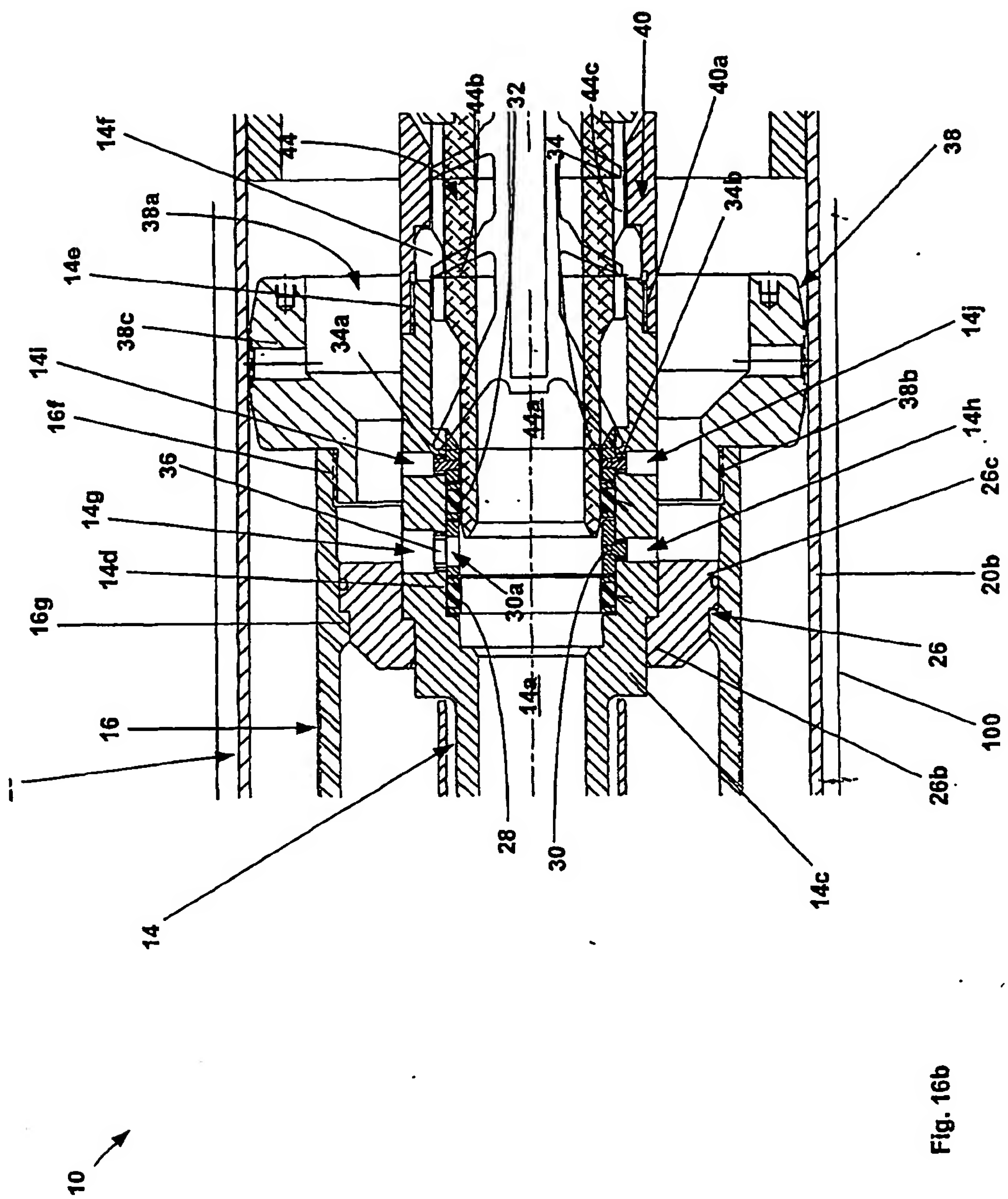
14j
14g
14h
26c
14d
14c
16g
26b
16e
26
26a
16a
16
14
16j
16l
16h
18d
14a
16c
24
24a
18c
16d
24b
20b
18
16b
18e
18a
20
22a
22
12d
18b
100
12c
14b
20a
12
12b
104a
104
20c
10
102

Fig. 16a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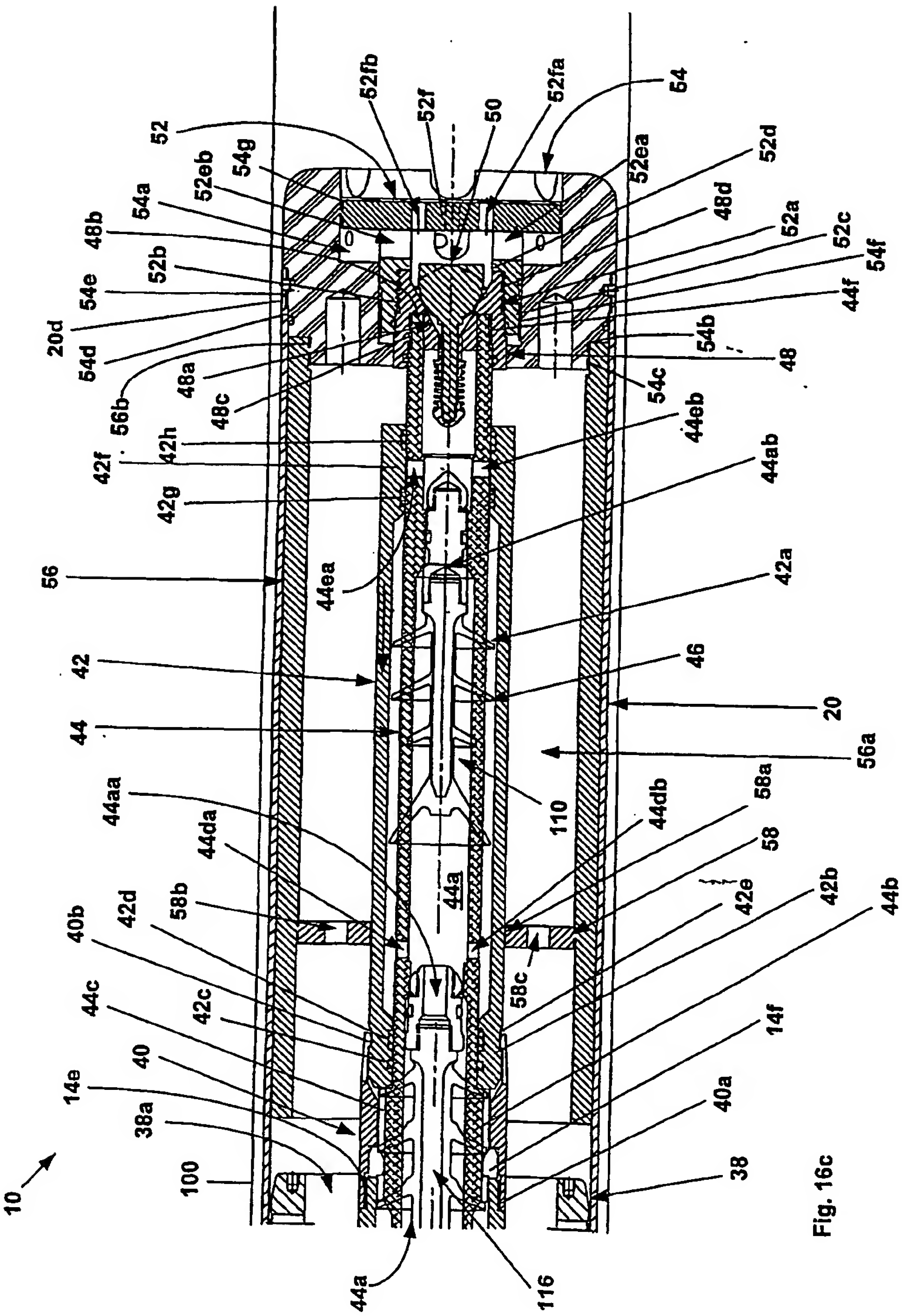
14e
38c
34a
14i
16f
36
14g
14d
16g
16
14
44
44b
32
44c
34
40
40a
34b
44a
30a
14a
28
30
38
14j
38b
14h
26c
20b
26
100
26b
14c
10

Fig. 16b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52fa
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54g
52eb
52ea
52d
54a
48b
48d
52a
52c
54f
52b
54e
44f
20d
54d
54b
48a
48
56b
48c
54c
42h
44eb
42f
44ab
42g
44ea
56
42a
42
46
20
44
56a
110
44aa
44da
44db
58a
58
44a
42e
42b
44b
58b
42d
40b
58c
44c
42c
40
14f
40a
14e
38a
38
100
10
44a
116

Fig. 16c

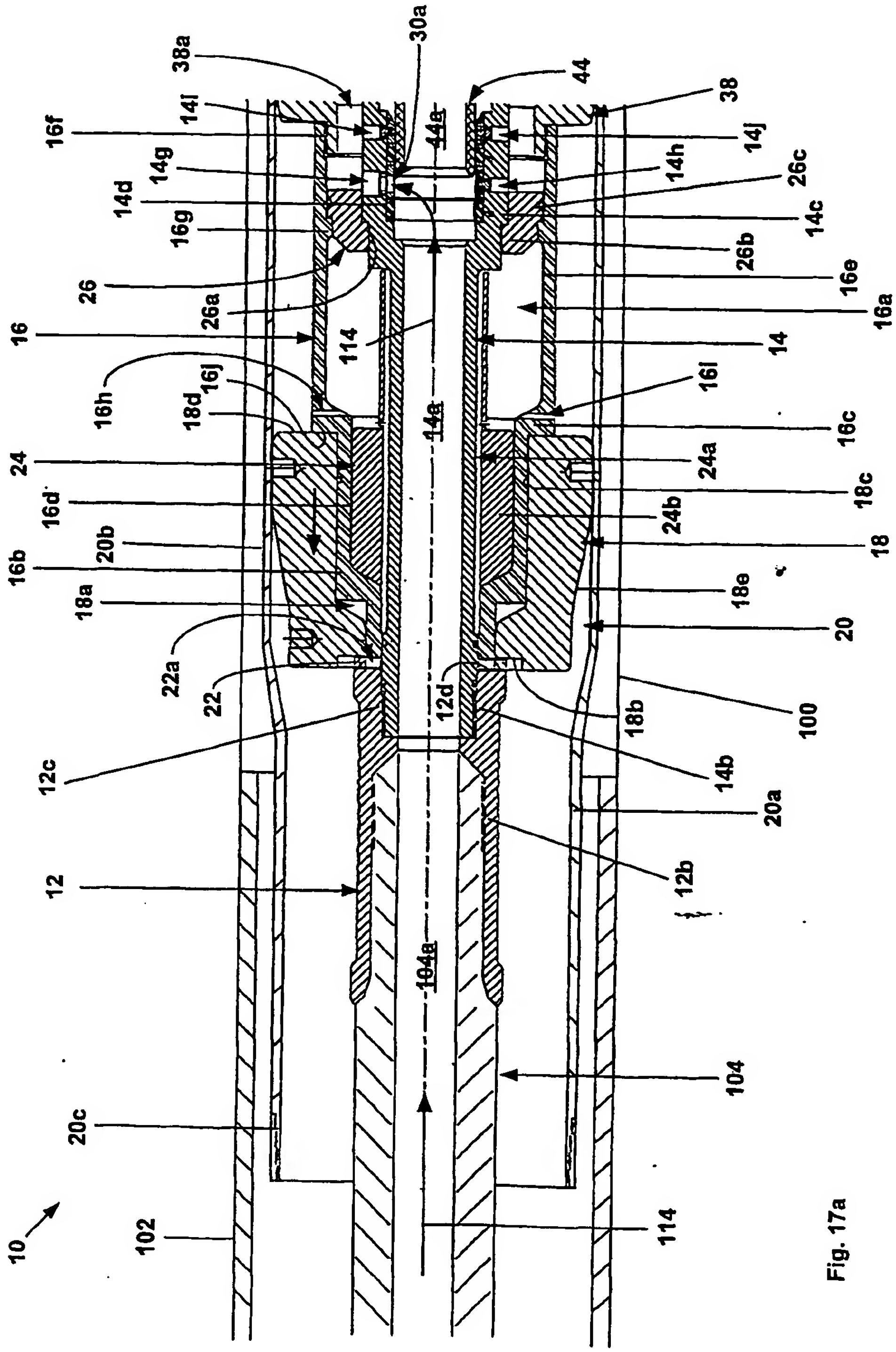
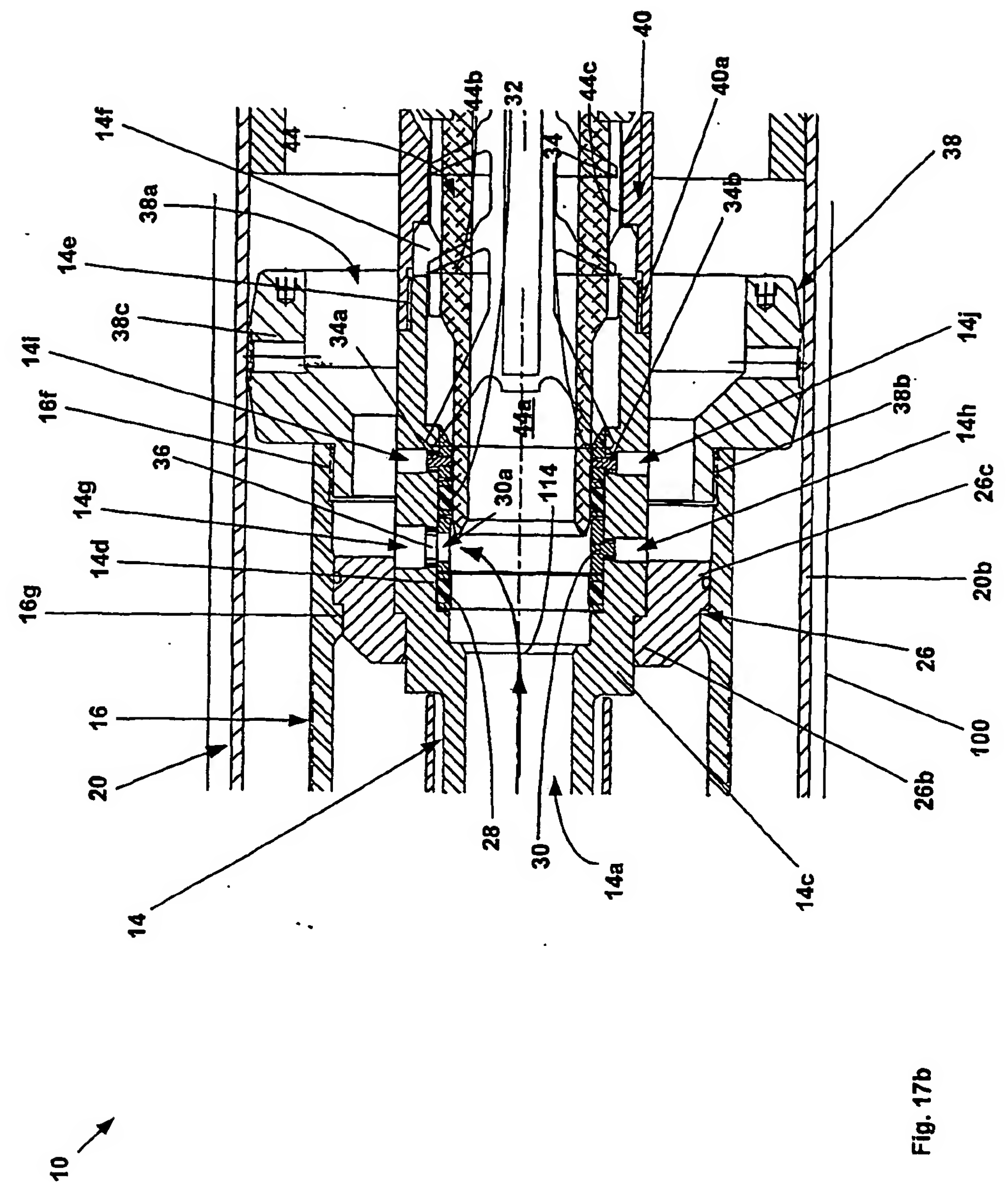

30a
38a
44
38
14i
44a
14j
16f
14g
14h
26c
14d
14c
16g
26b
26
16e
26a
16a
114
16
14
16h
16j
16i
18d
14a
16c
24
24a
18c
16d
24b
20b
16b
18
18a
18e
20
22a
22
12d
18b
100
12c
14b
20a
12
12b
104a
104
20c
10
102
114

Fig. 17a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14
14a
14c
14d
14e
14f
14g
14h
14i
14j
16
16f
16g
20
20b
26
26b
26c
28
30
30a
32
34
34a
34b
36
38
38a
38b
38c
40
40a
44
44a
44b
44c
100
114

Fig. 17b

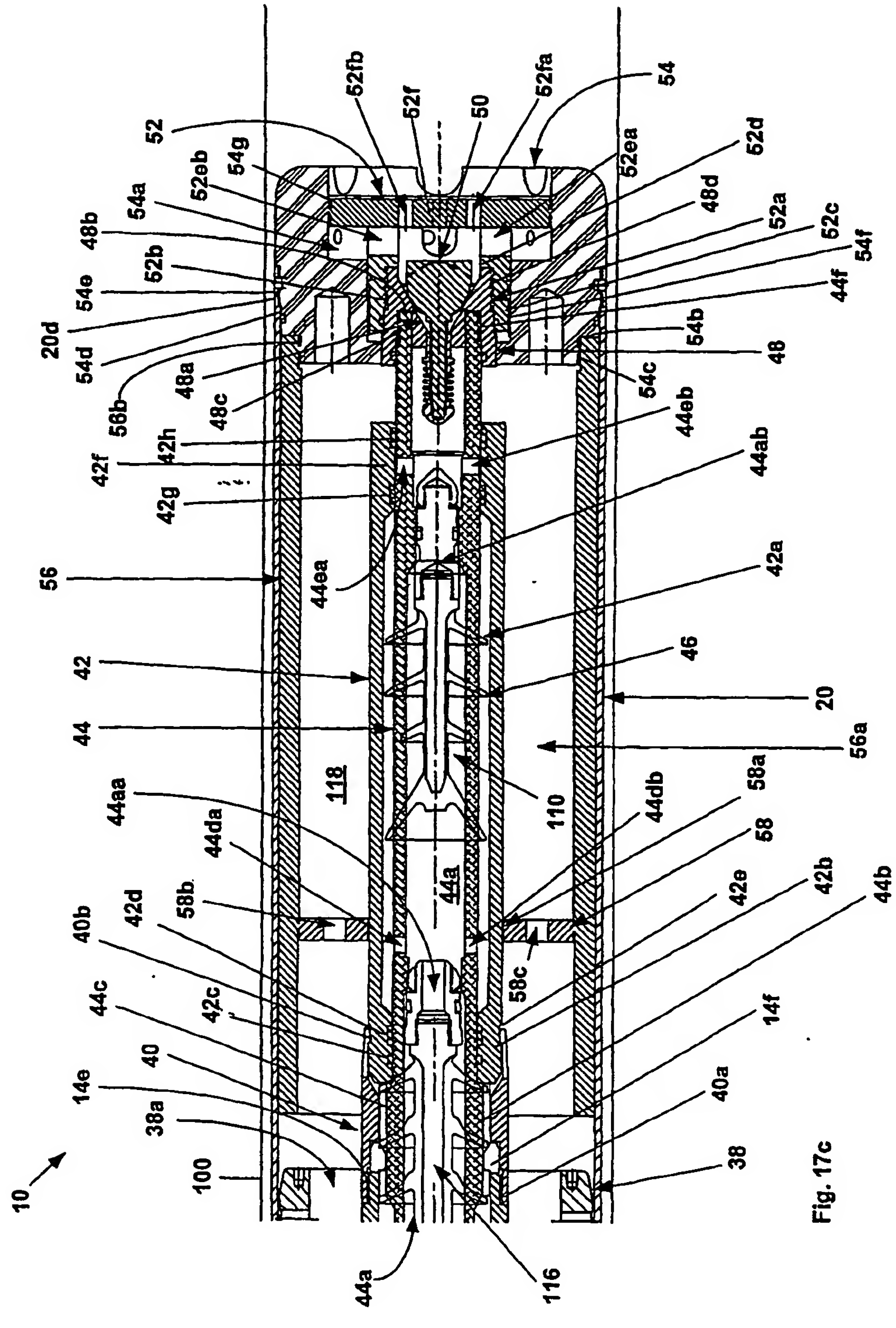

10
100
38a
14e
40
44c
42c
40b
42d
58b
44da
44aa
118
44
42
56
42g
42f
42h
56b
48c
48a
54d
20d
54e
52b
48b
54a
52eb
54g
52
52fb
52f
50
52fa
54
52ea
52d
48d
52a
52c
54f
44f
54b
48
54c
44eb
44ab
44ea
42a
46
20
56a
110
44a
44db
58a
58
42e
42b
44b
58c
14f
40a
38
116

Fig. 17c

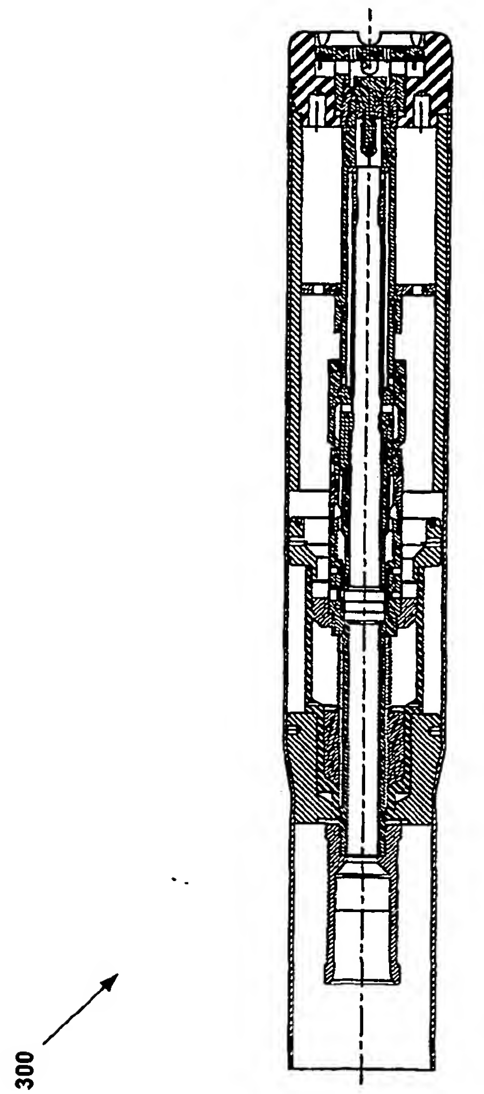
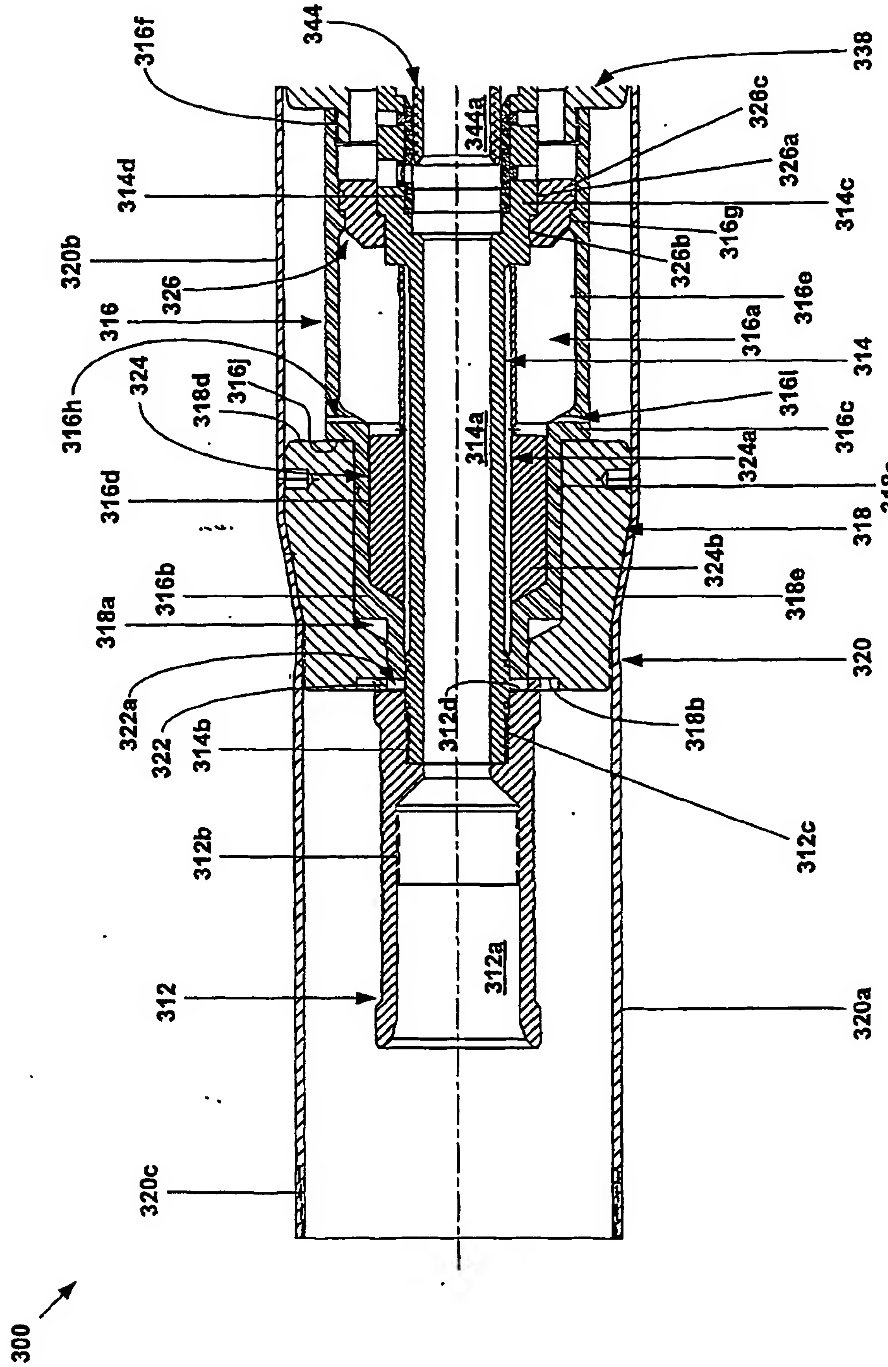


Fig. 18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312b
312c
312d
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314a
314b
314c
314d
316
316a
316b
316c
316d
316e
316f
316g
316h
316j
316l
318
318a
318b
318c
318d
318e
320
320a
320b
320c
322
322a
324
324a
324b
326
326a
326b
326c
338
344
344a

Fig. 18a

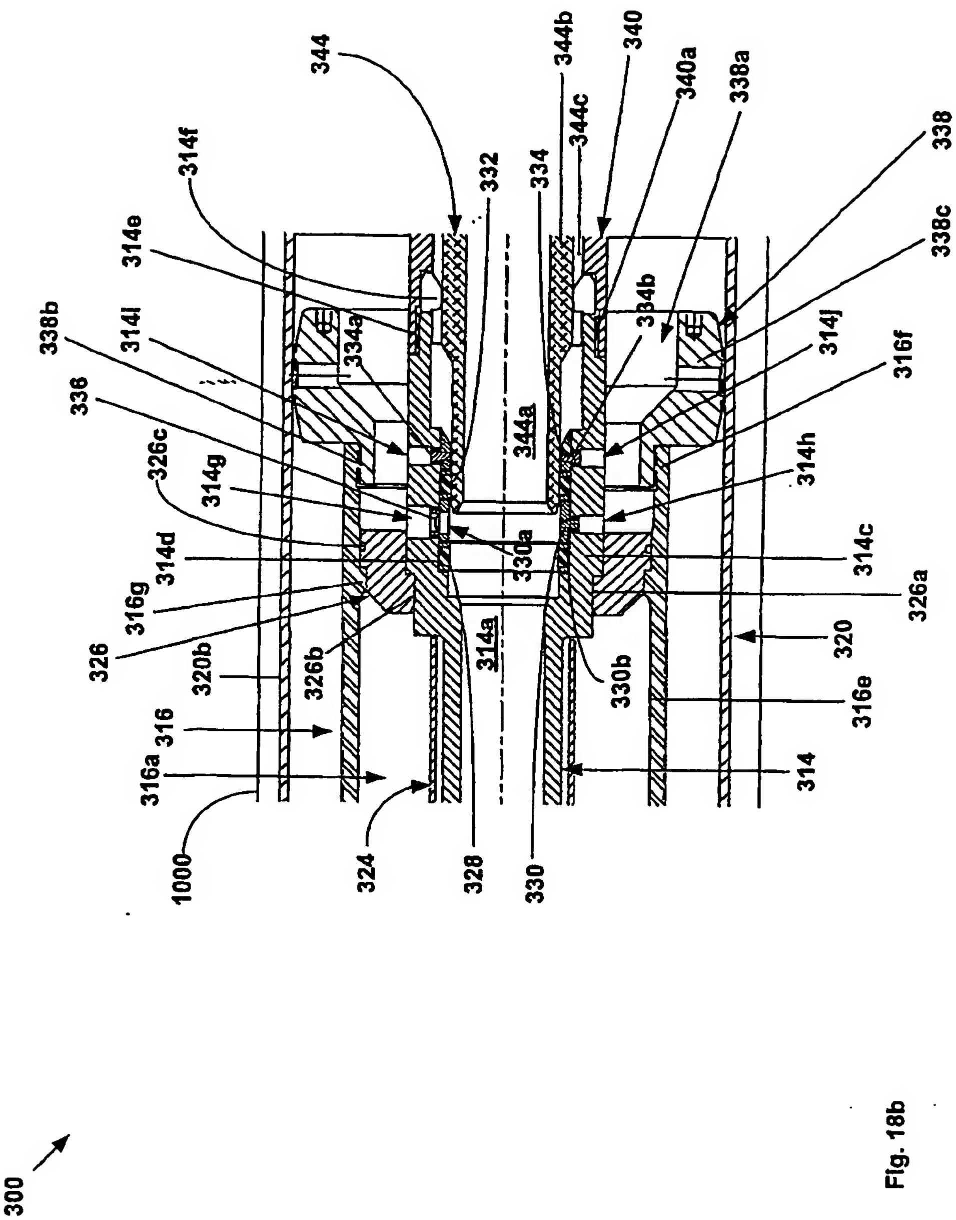

344
344b
340
340a
338a
338
338c
314f
314e
332
334
344c
338b
314l
334a
334b
314j
316f
336
344a
326c
314g
314h
330a
314d
314c
316g
326a
326
320b
326b
314a
330b
320
316e
316
316a
314
1000
324
328
330
300

Fig. 18b

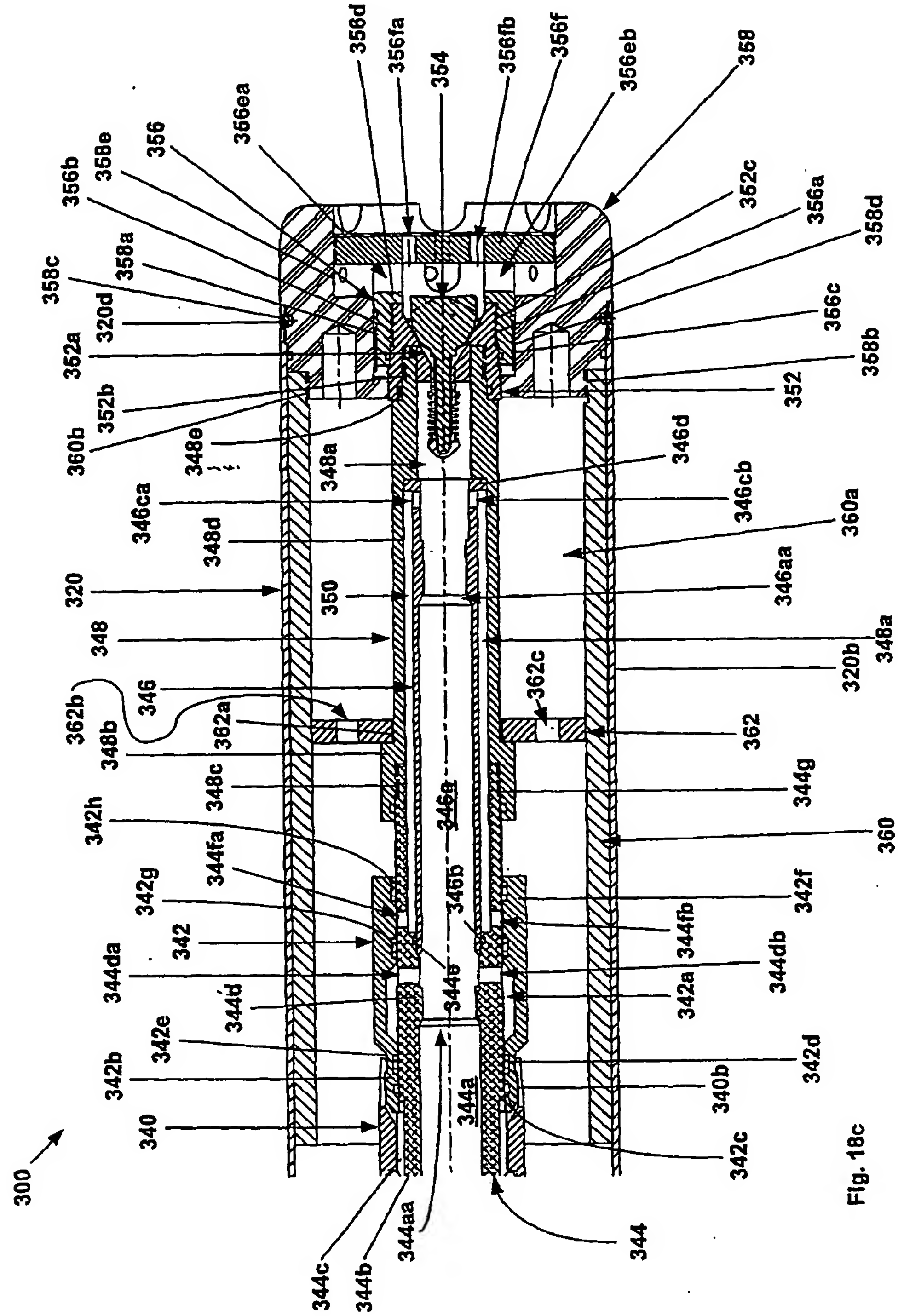

300
340
342b
342e
344da
342
342g
344fa
342h
348b
362b
346
348
320
346ca
360b
352b
352a
320d
358c
358a
356b
358e
356
356ea
356d
356fa
354
356fb
356f
356eb
358
352c
356a
358d
356c
358b
352
348e
348a
346d
346cb
360a
348d
350
346aa
348a
320b
362c
362a
362
348c
346a
344g
360
346b
342f
344fb
344e
344d
344db
342a
342d
340b
344a
342c
344aa
344b
344c
344

Fig. 18c

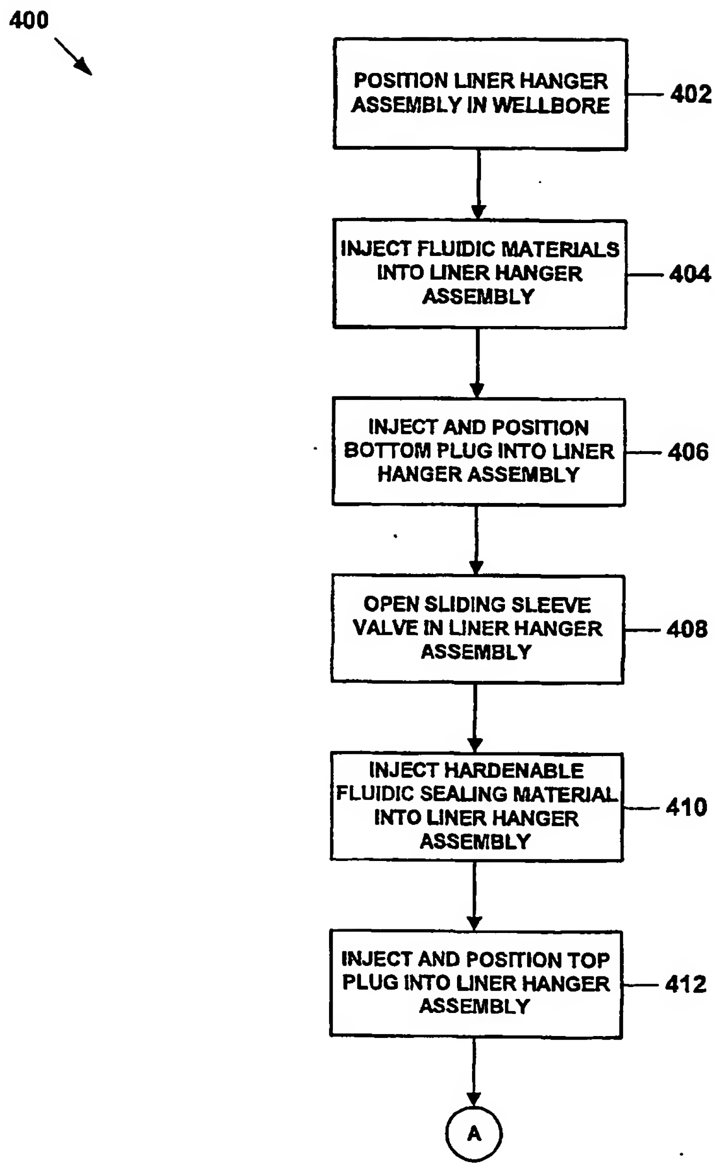

400
POSITION LINER HANGER ASSEMBLY IN WELLBORE
402
INJECT FLUIDIC MATERIALS INTO LINER HANGER ASSEMBLY
404
INJECT AND POSITION BOTTOM PLUG INTO LINER HANGER ASSEMBLY
406
OPEN SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
408
INJECT HARDENABLE FLUIDIC SEALING MATERIAL INTO LINER HANGER ASSEMBLY
410
INJECT AND POSITION TOP PLUG INTO LINER HANGER ASSEMBLY
412
A

Fig. 19a

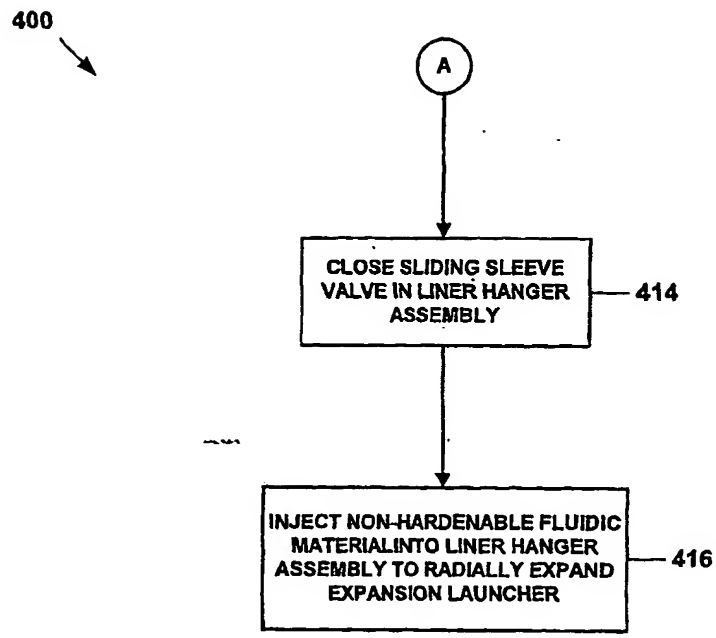

400
A
CLOSE SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
414
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
416

Fig. 19b

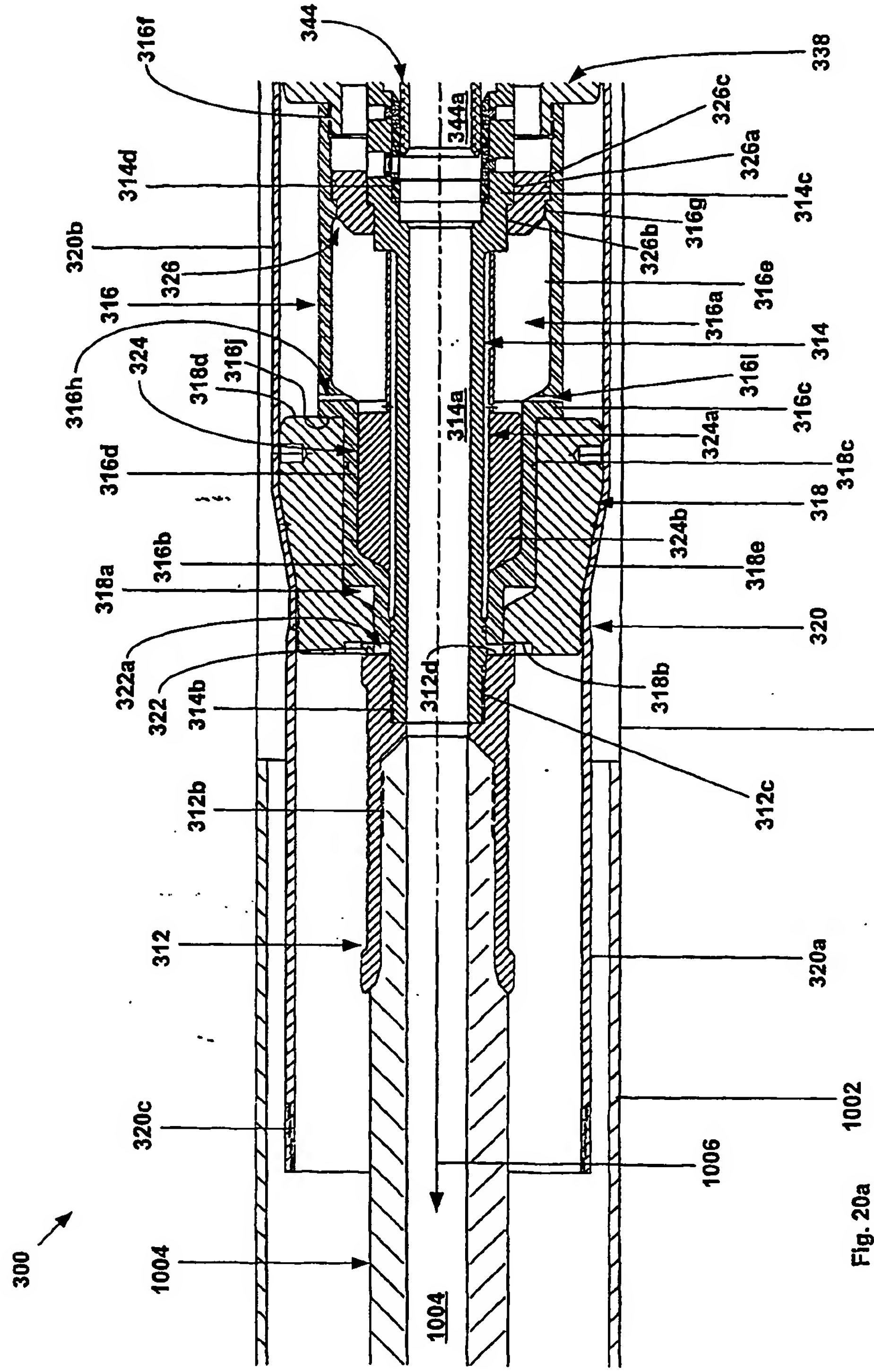
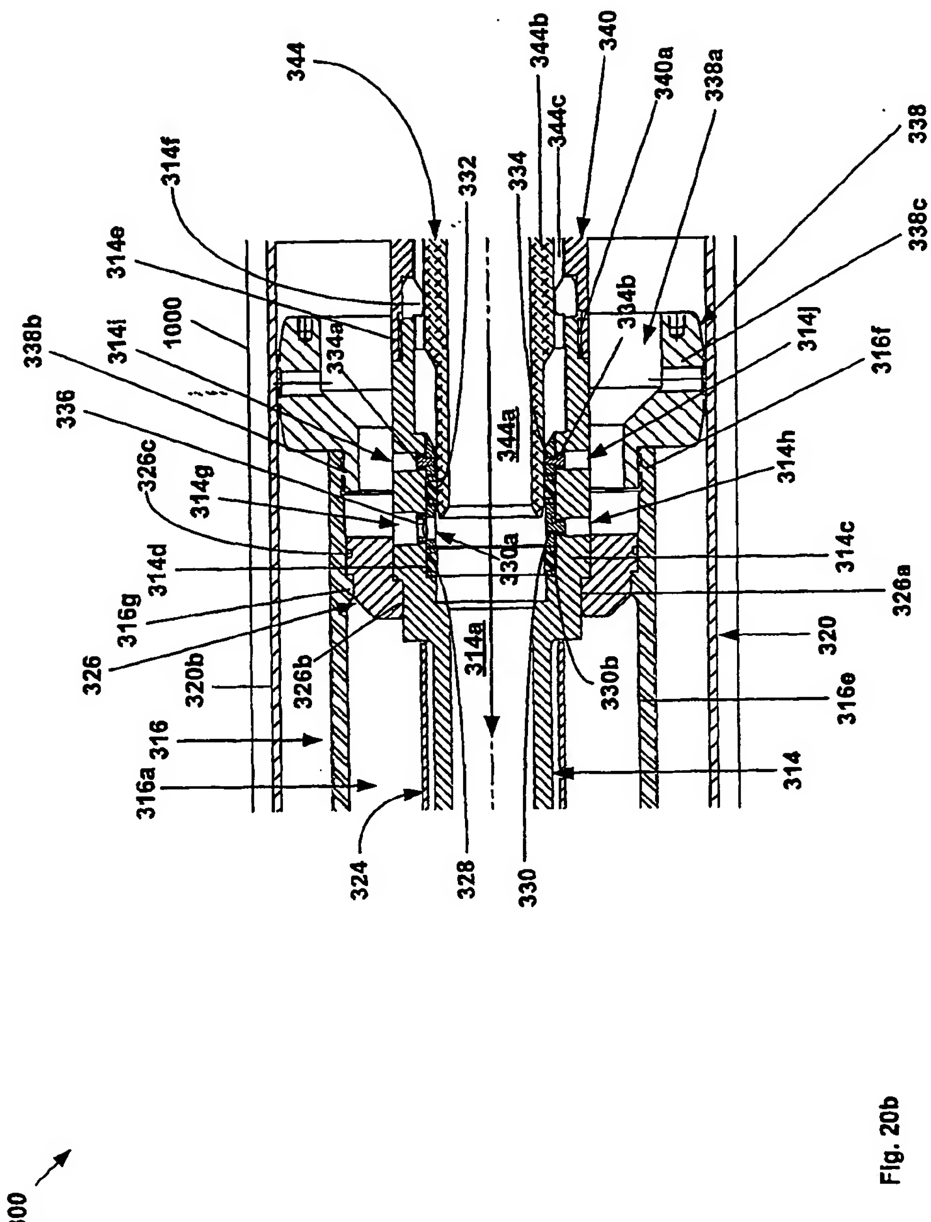

316f
344
338
344a
326c
326a
314d
314c
316g
320b
326b
326
316e
316
316a
314
324
318d
316j
316h
316l
316c
314a
324a
316d
318c
318
324b
316b
318e
318a
320
322a
312d
318b
322
314b
1000
312c
312b
312
320a
320c
1002
1006
300
1004
1004

Fig. 20a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314f
332
334
344b
344c
340
340a
338a
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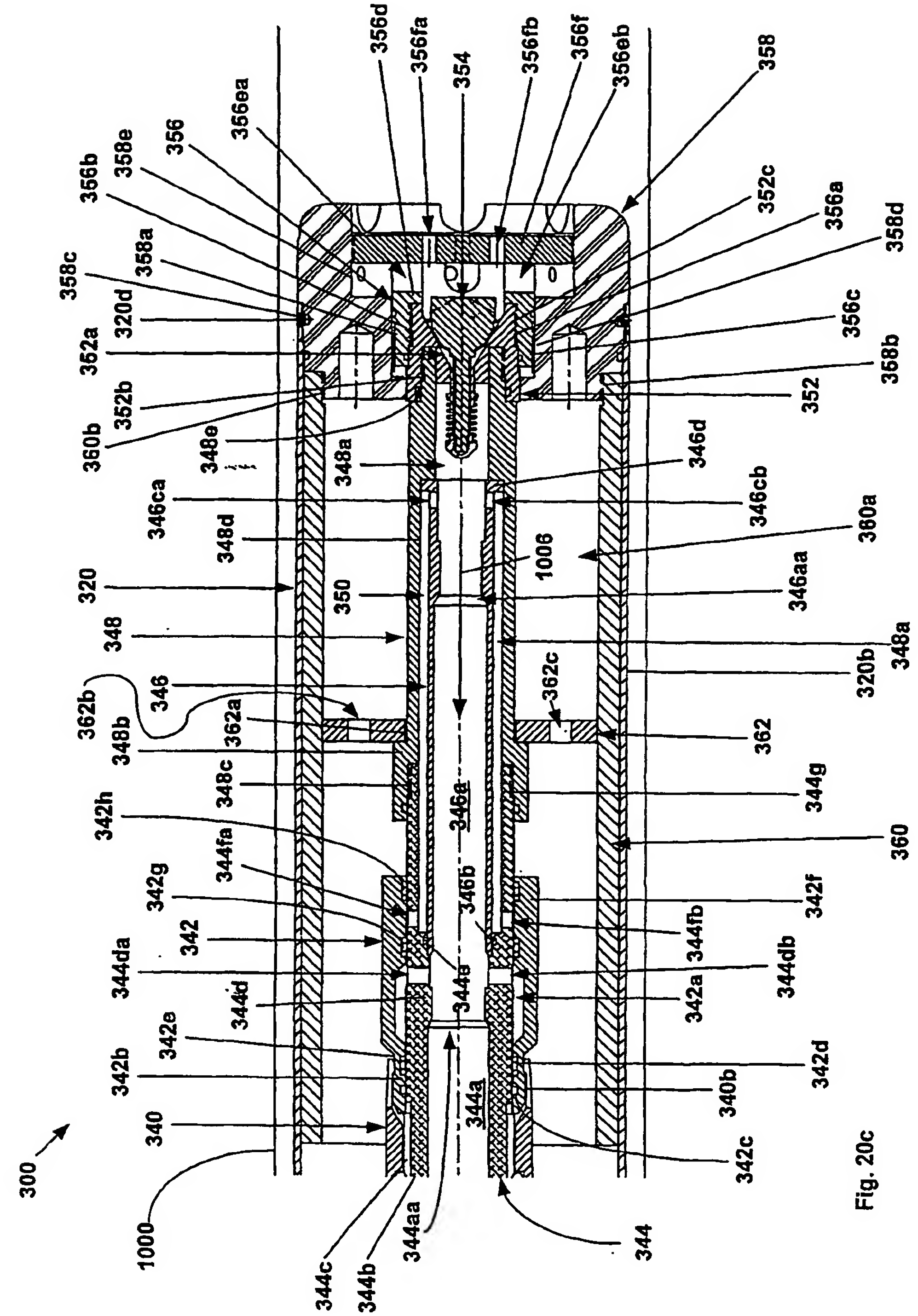
338c
314e
1000
314i
338b
336
326c
314g
314d
316g
326
320b
326b
316
316a
324
328
330
334a
334b
344a
330a
314a
330b
314j
316f
314h
314c
326a
320
316e
314
300

Fig. 20b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1000
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320b
320d
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340b
342
342a
342b
342c
342d
342e
342f
342g
342h
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344aa
344b
344c
344d
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344db
344e
344fa
344fb
344g
346
346a
346aa
346b
346ca
346cb
346d
348
348a
348b
348c
348d
348e
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352
352a
352b
352c
354
356
356a
356b
356c
356d
356ea
356eb
356f
356fa
356fb
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358b
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358d
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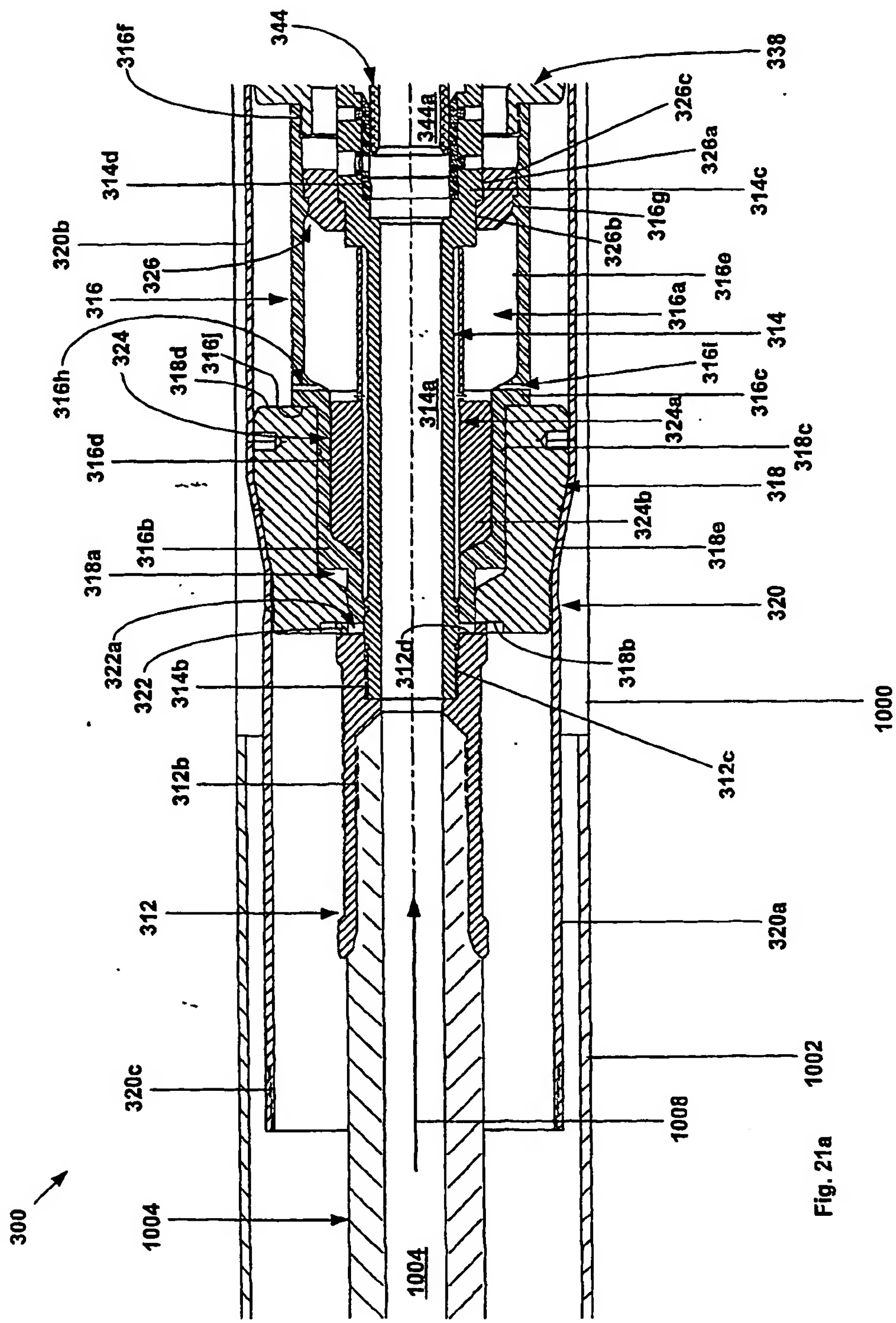
360
360a
360b
362
362a
362b
362c
1006

Fig. 20c


300
1004
320c
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312b
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322a
318a
316b
316d
324
318d
316j
316h
316
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314d
316f
344
344a
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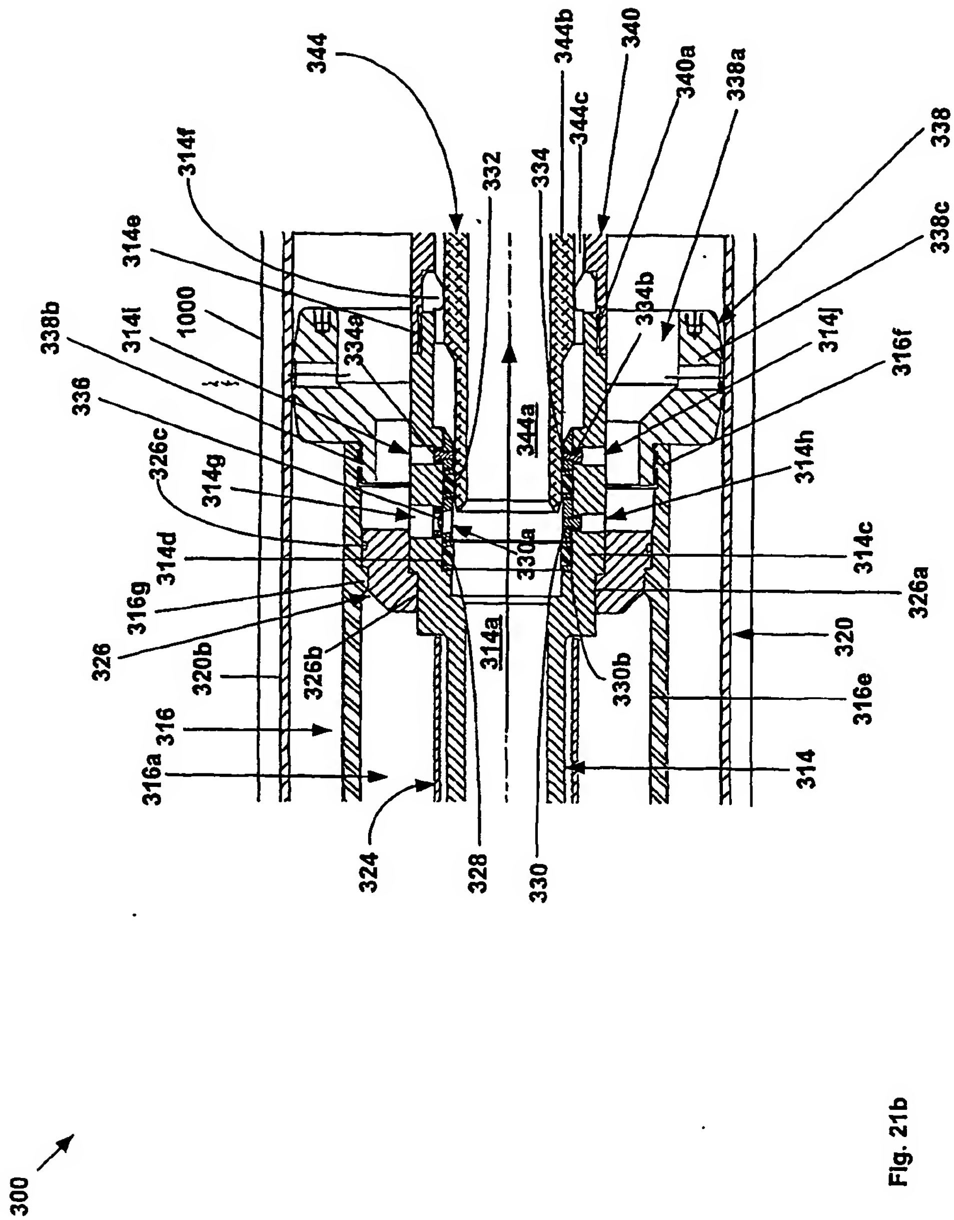
326c
326a
314c
316g
326b
316e
316a
314
316i
316c
324a
318c
318
324b
318e
320
318b
312d
314a
1000
312c
320a
1002
1008
1004

Fig. 21a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344b
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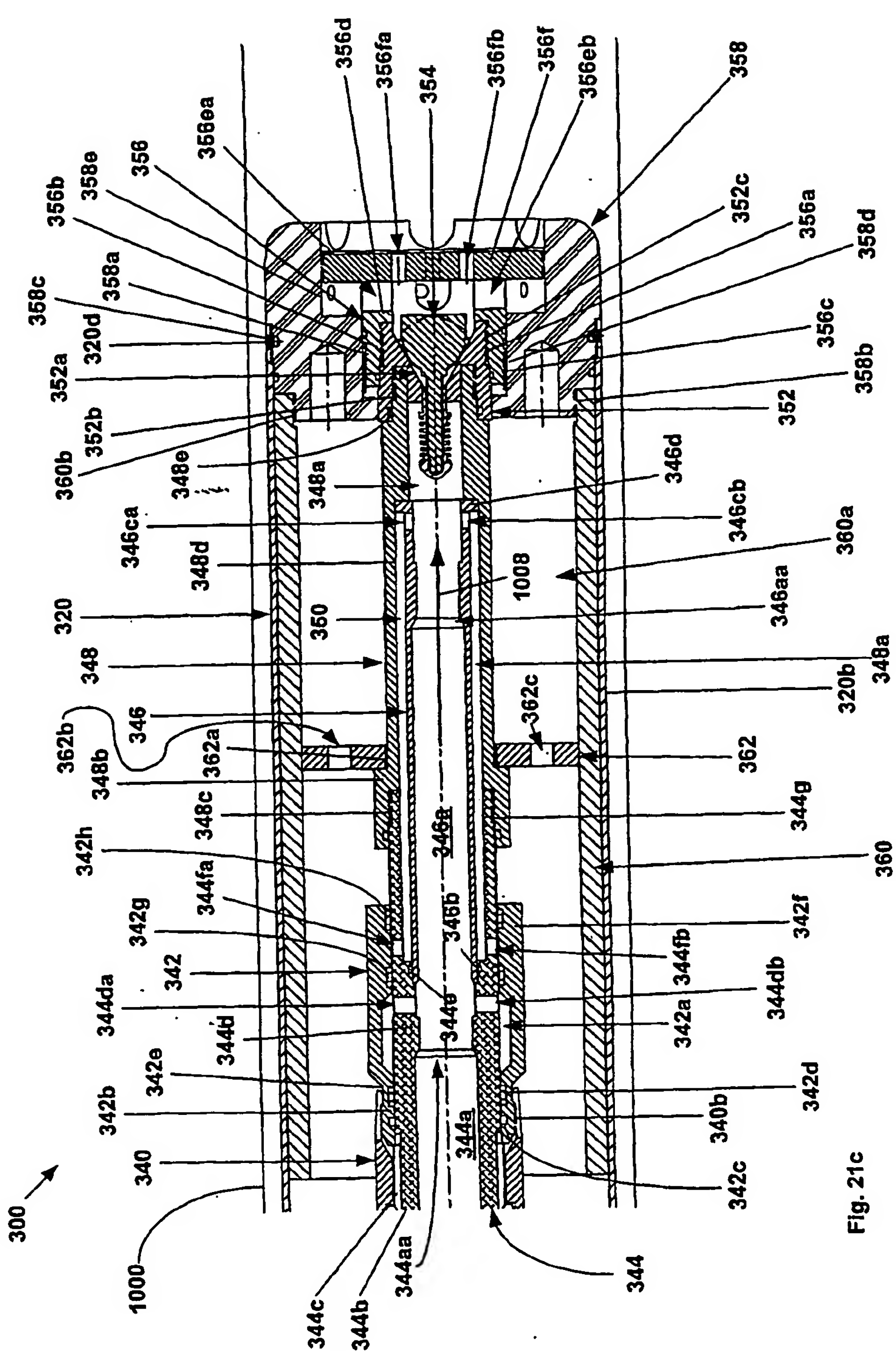
340a
338a
338
338c
314f
332
334
344c
314e
1000
314i
338b
334a
334b
314j
316f
336
344a
326c
314g
314h
330a
314d
314c
316g
326a
326
326b
314a
330b
320
320b
316e
316
316a
314
324
328
330
300

Fig. 21b


356d
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354
356fb
356f
356eb
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356ea
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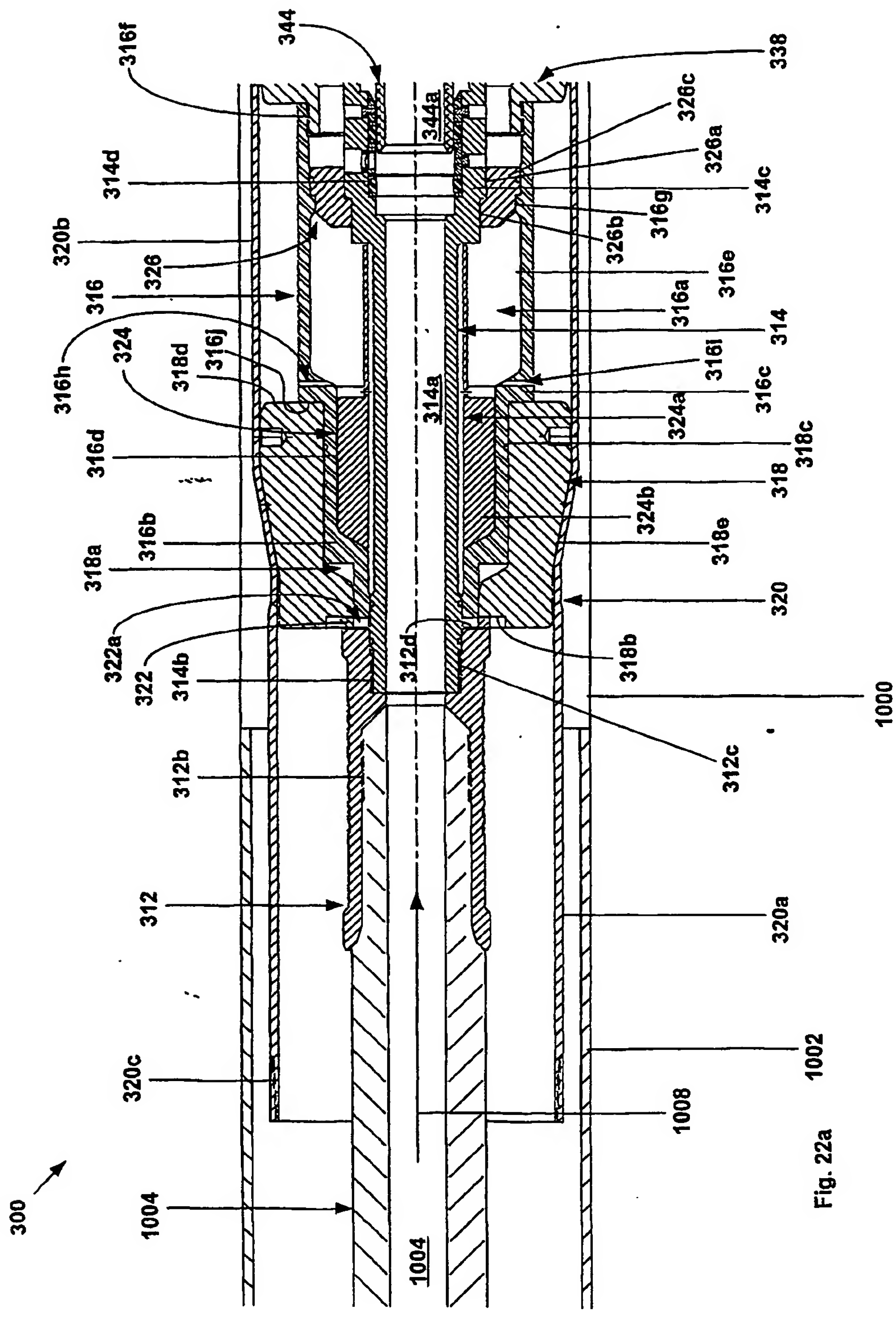
358e
356b
352c
356a
358d
358a
358c
320d
356c
352a
358b
352b
352
360b
348e
348a
346d
346ca
346cb
348d
360a
1008
360
346aa
320
348
348a
320b
346
362c
362b
362a
348b
362
348c
344g
342h
346a
360
344fa
342g
346b
342f
342
344fb
344da
344db
344d
344e
342a
342e
342d
342b
340b
340
344a
342c
300
1000
344c
344b
344aa
344

Fig. 21c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344a
326c
326a
314d
314c
316g
320b
326b
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316e
316
316a
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316h
324
318d
316j
316i
316c
314a
324a
316d
318c
318
324b
316b
318e
318a
320
322a
322
312d
318b
314b
1000
312c
312b
312
320a
320c
1002
1008
300
1004
1004

Fig. 22a

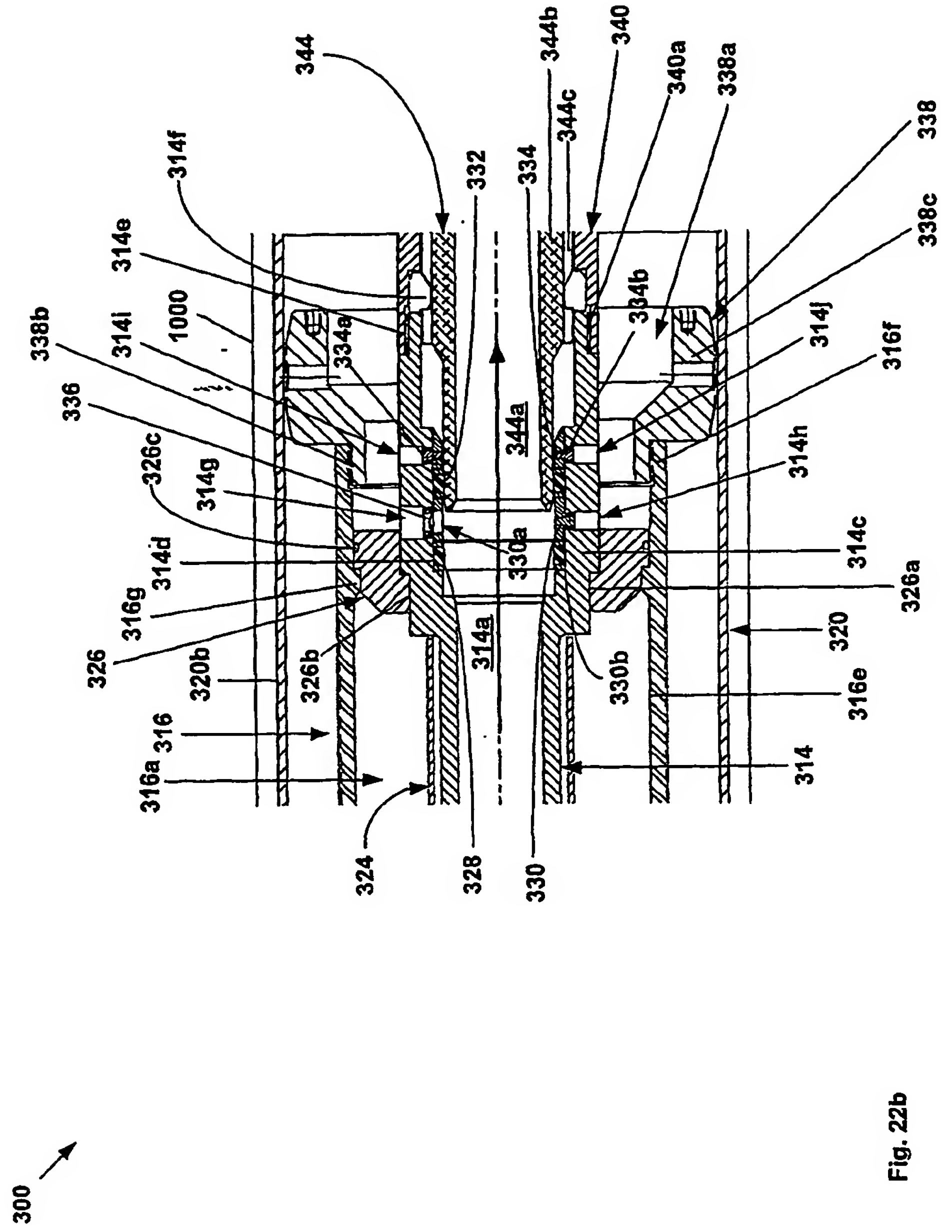

300
344
314f
314e
332
334
344b
344c
340
340a
338a
338
338c
338b
314i
1000
334e
336
326c
314g
314d
316g
326
320b
326b
316
316a
324
328
330
314a
344a
330a
334b
314j
316f
314h
314c
326a
320
330b
316e
314

Fig. 22b

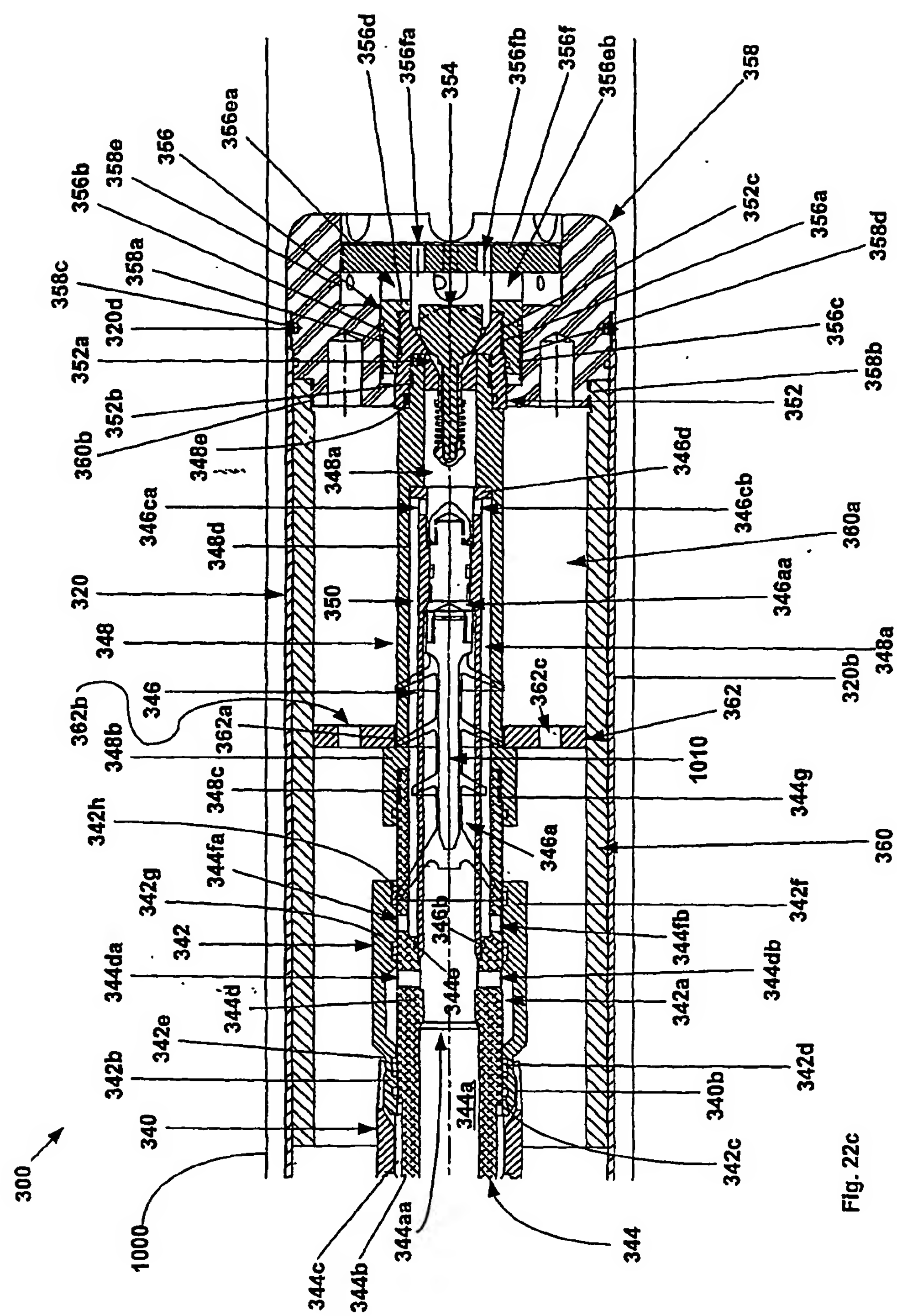

300
1000
320
320b
320d
340
340b
342
342a
342b
342c
342d
342e
342f
342g
342h
344
344a
344aa
344b
344c
344d
344da
344db
344e
344fa
344fb
344g
346
346a
346aa
346b
346ca
346cb
346d
348
348a
348b
348c
348d
348e
350
352
352a
352b
352c
354
356
356a
356b
356c
356d
356ea
356eb
356f
356fa
356fb
358
358a
358b
358c
358d
358e
360
360a
360b
362
362a
362b
362c
1010

Fig. 22c

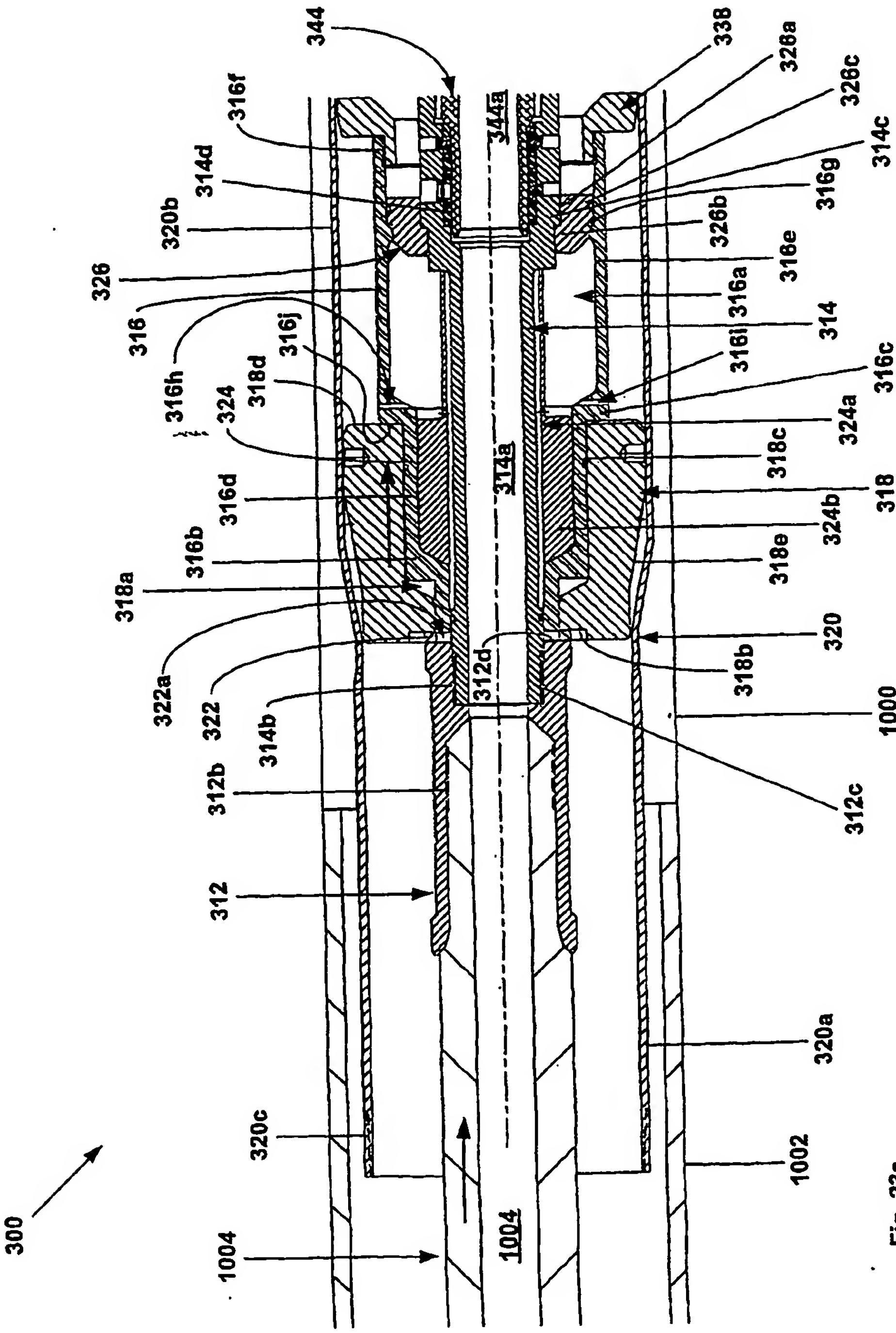

344
344a
316f
314d
320b
326
316
316h
316j
318d
324
316d
316b
318a
322a
322
314b
312b
312
320c
300
1004
1004
338
326a
326c
314c
316g
326b
316e
316a
314
316i
316c
324a
318c
314a
318
324b
318e
320
318b
312d
1000
312c
320a
1002

Fig. 23a

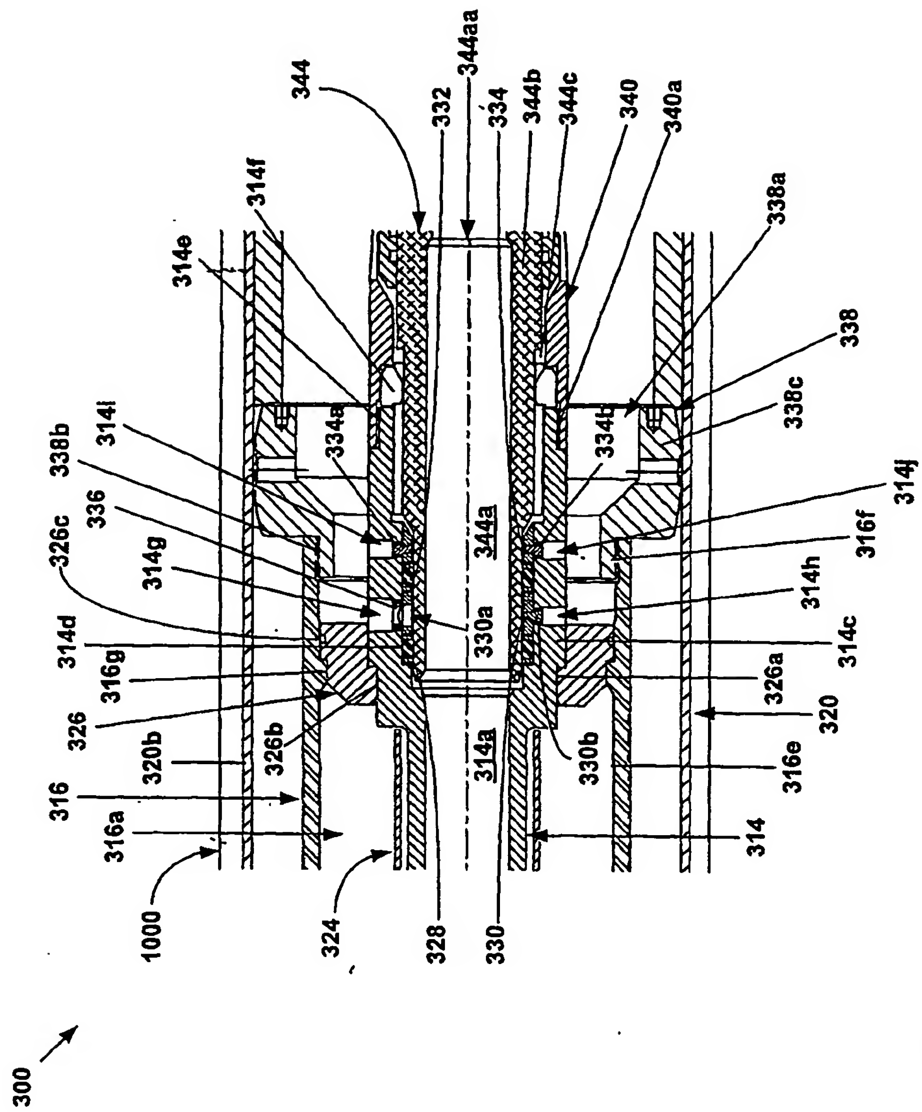

300
1000
316a
316
320b
326
326b
316g
314d
326c
314g
336
338b
314i
334a
314e
314f
344
332
344aa
334
344b
344c
340
340a
338a
338
338c
334b
314j
316f
314h
314c
326a
320
316e
314
330b
330a
344a
314a
324
328
330

Fig. 23b

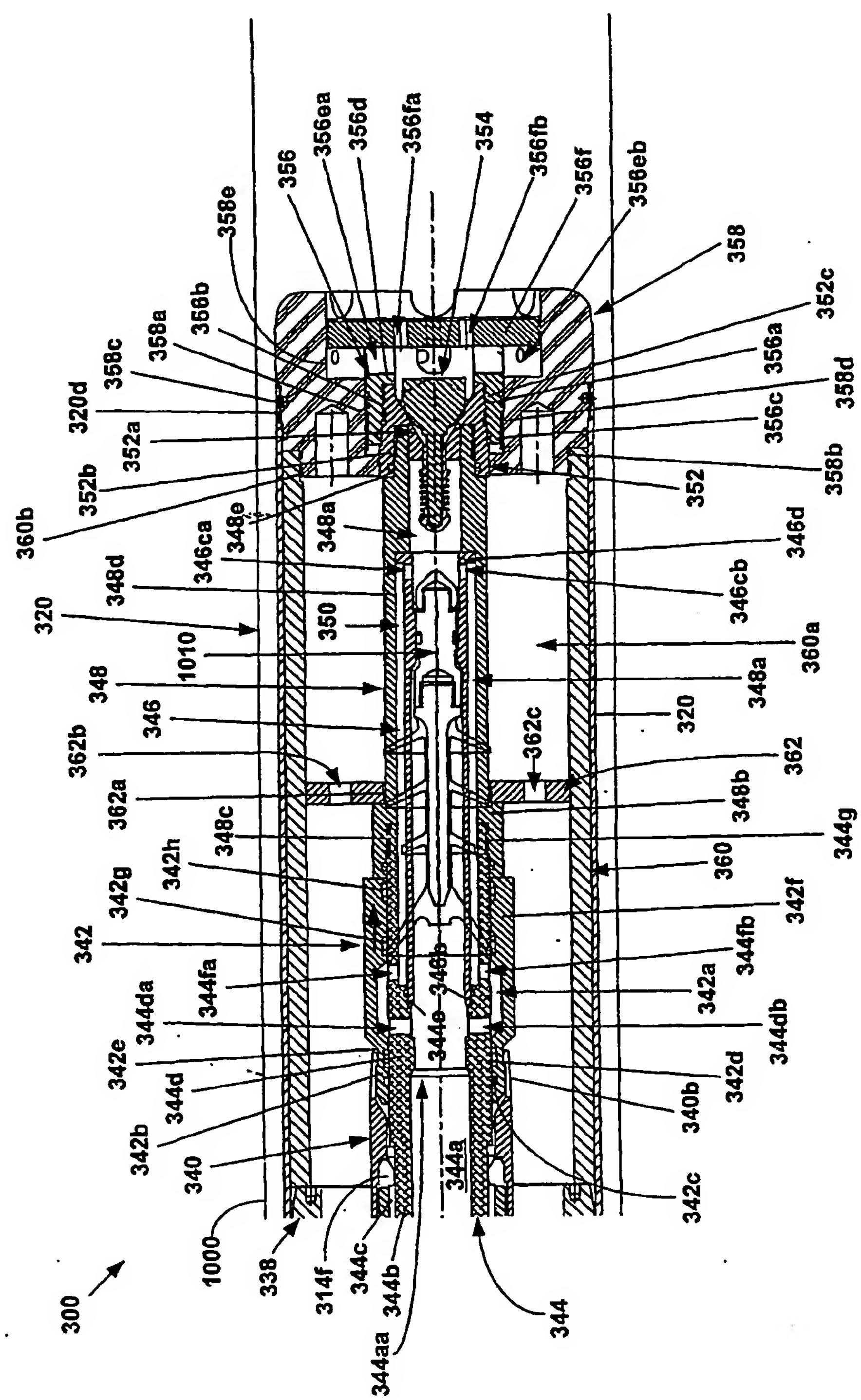
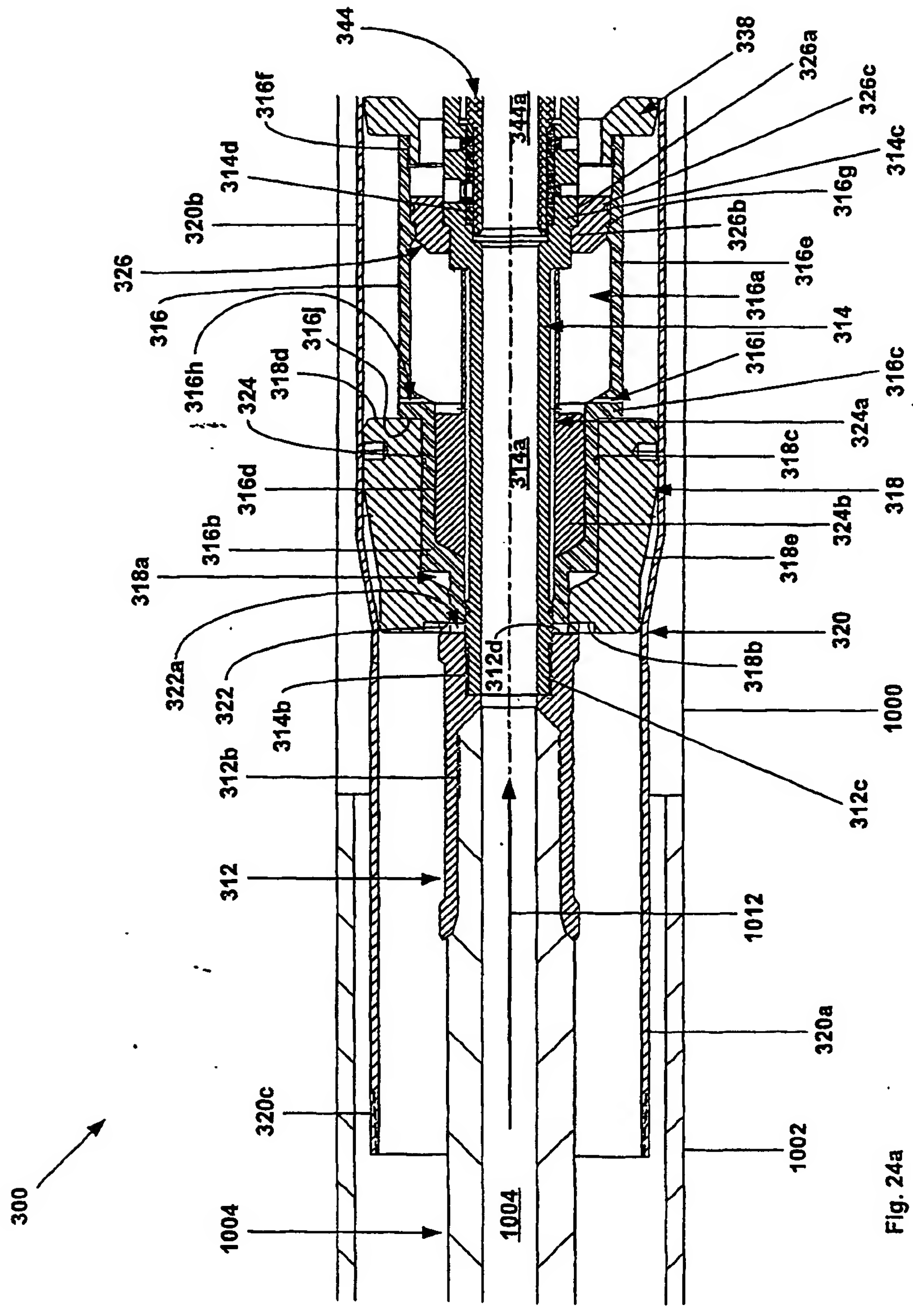

358e
356
356ea
356d
356fa
354
356fb
356f
356eb
358
352c
356a
358d
356c
358b
352
358c
358a
356b
320d
352a
352b
360b
348e
348a
346ca
346d
348d
346cb
320
350
1010
360a
348
348a
346
362c
320
362b
362
362a
348b
348c
344g
342h
360
342g
342f
342
344fb
344fa
346b
342a
344da
344e
344db
342e
344d
342d
340b
342b
340
344a
342c
1000
338
314f
344c
344b
344aa
344
300

Fig. 23c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344
344a
338
326a
326c
314c
316g
326b
316e
316a
314
316i
316c
324a
318c
318
324b
318e
320
318b
1000
312c
1012
320a
1002
316f
314d
320b
326
316
316j
316h
318d
324
314a
316d
316b
318a
322a
322
312d
314b
312b
312
320c
1004

Fig. 24a

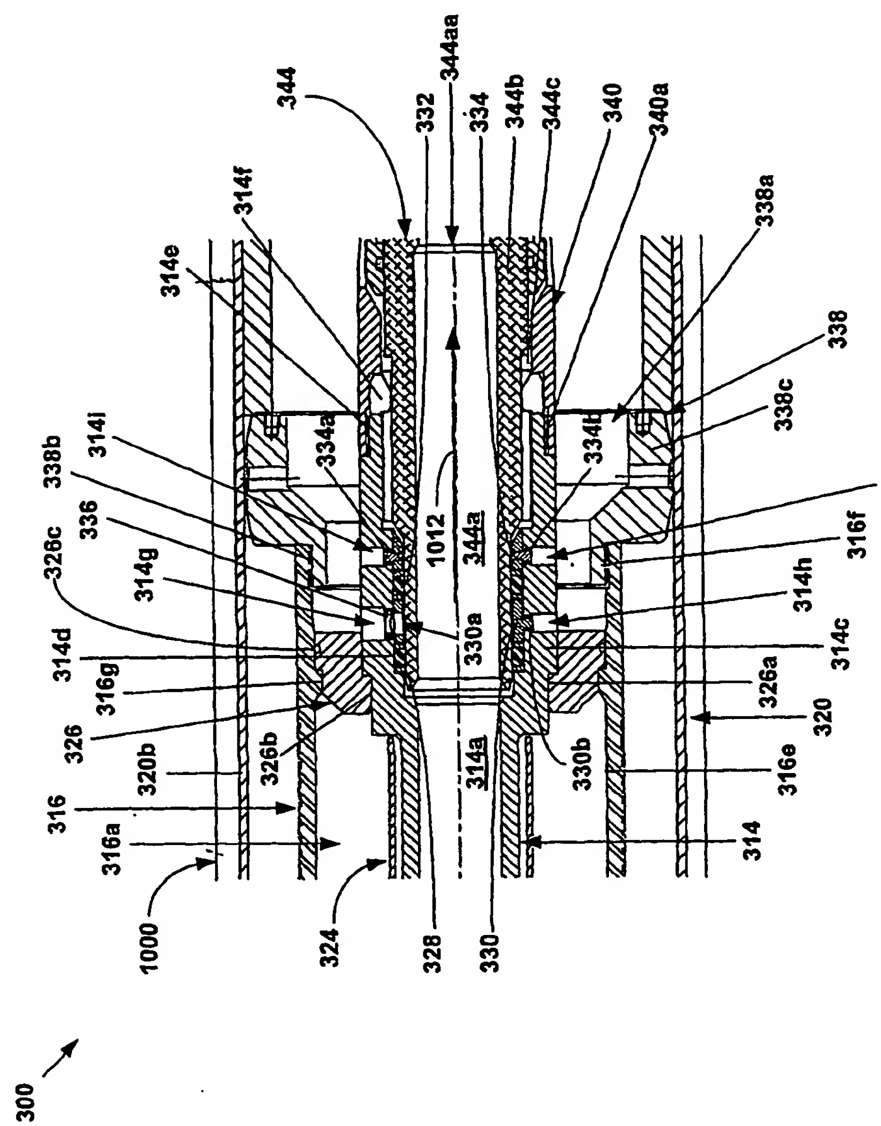

300
1000
324
328
330
316a
316
320b
326b
326
316g
314d
326c
314g
336
338b
314i
334a
1012
344a
314a
330a
330b
314e
314f
344
332
344aa
334
344b
344c
340
340a
338a
338
338c
334b
314j
316f
314h
314c
326a
320
316e
314

Fig. 24b

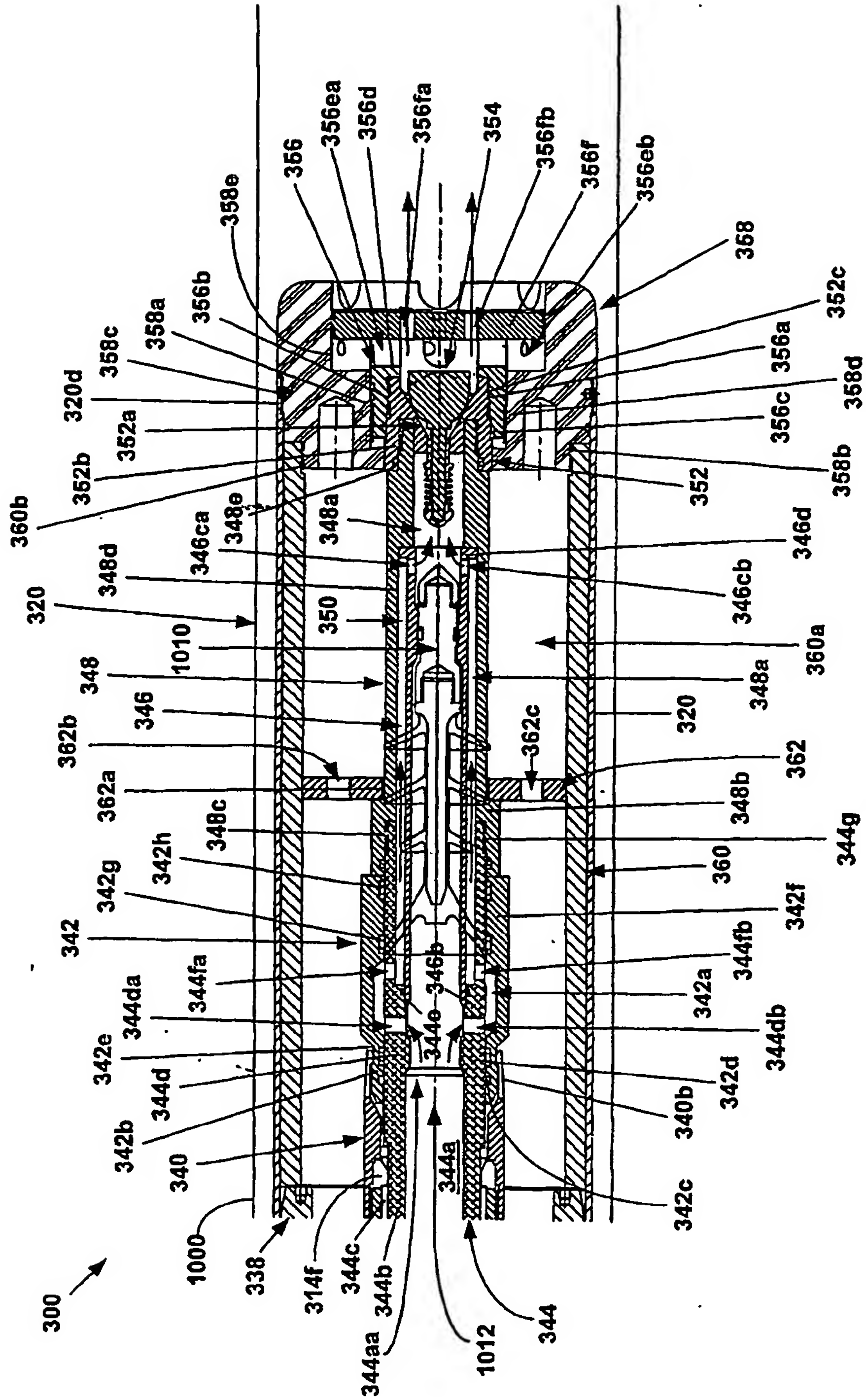

300
1000
338
314f
344c
344b
344aa
1012
344
342c
340b
342d
344a
340
342b
344d
342e
344da
344fa
344e
346b
342
342g
342h
348c
362a
362b
346
348
1010
350
320
348d
346ca
348e
348a
360b
352b
352a
320d
358c
358a
356b
358e
356
356ea
356d
356fa
354
356fb
356f
356eb
358
352c
356a
358d
356c
358b
352
346d
346cb
360a
348a
320
362c
362
348b
344g
360
342f
344fb
342a
344db

Fig. 24c

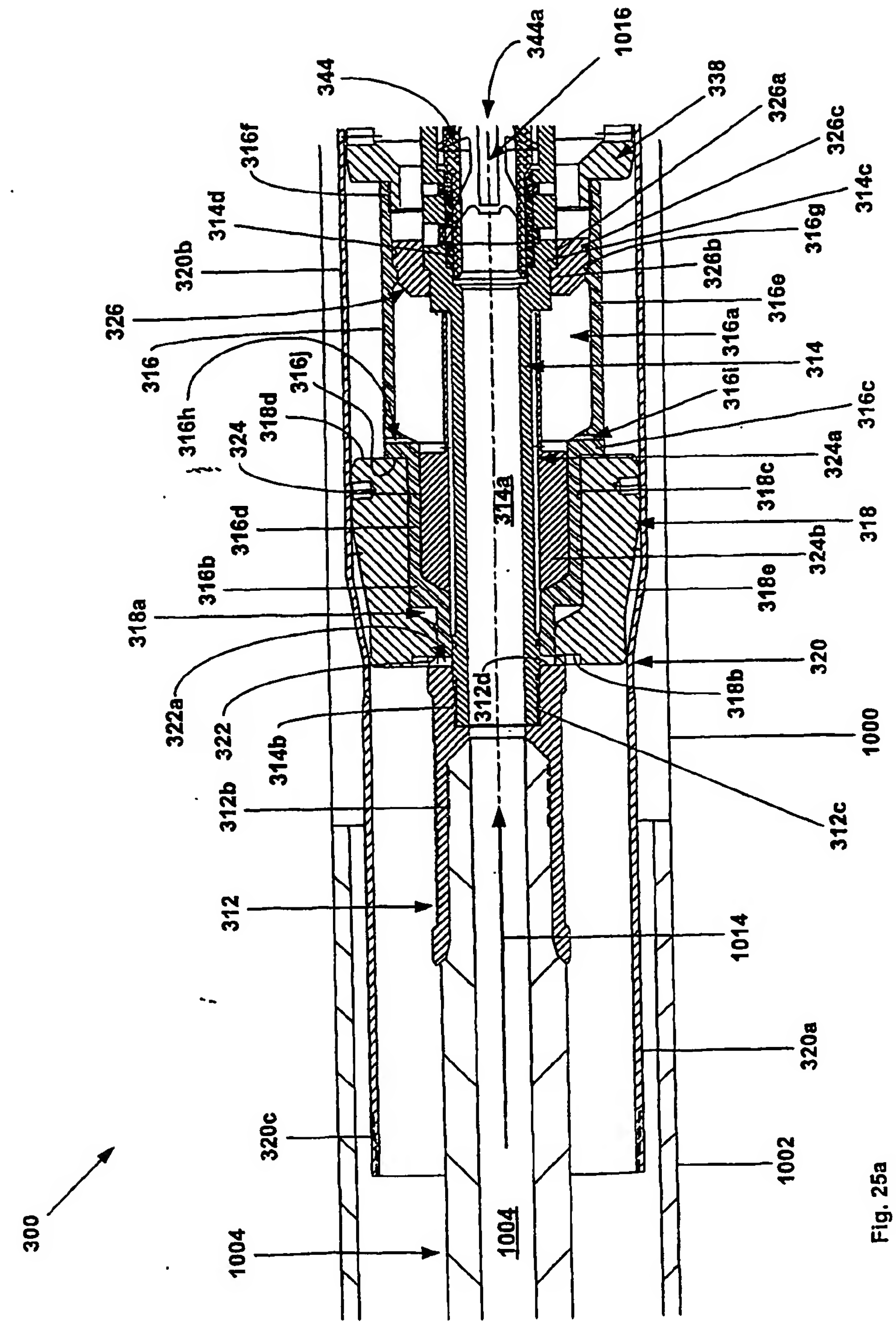

300
1004
1004
320c
312
312b
314b
322
322a
318a
316b
316d
324
316h
316
326
320b
314d
316f
344
344a
1016
338
326a
326c
314c
316g
326b
316e
316a
314
316i
316c
324a
318c
318
324b
318e
320
318b
1000
312c
1014
320a
1002
318d
316j
314a
312d

Fig. 25a

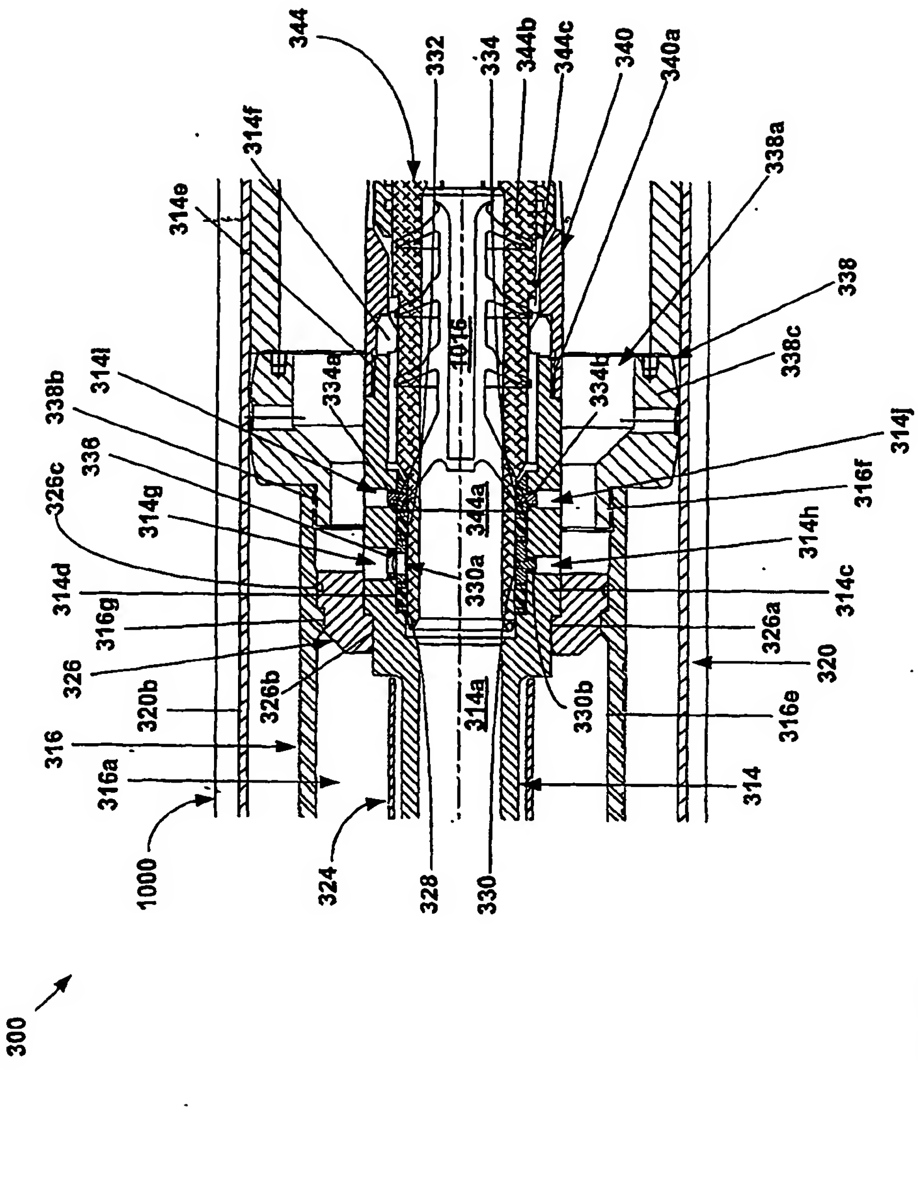

300
1000
316a
316
320b
326
316g
314d
326c
314g
336
338b
314i
324
326b
328
314a
330a
344a
334a
1016
314e
314f
344
332
334
344b
344c
340
340a
338a
338
338c
314j
316f
314h
314c
326a
320
316e
330b
314
330

Fig. 25b

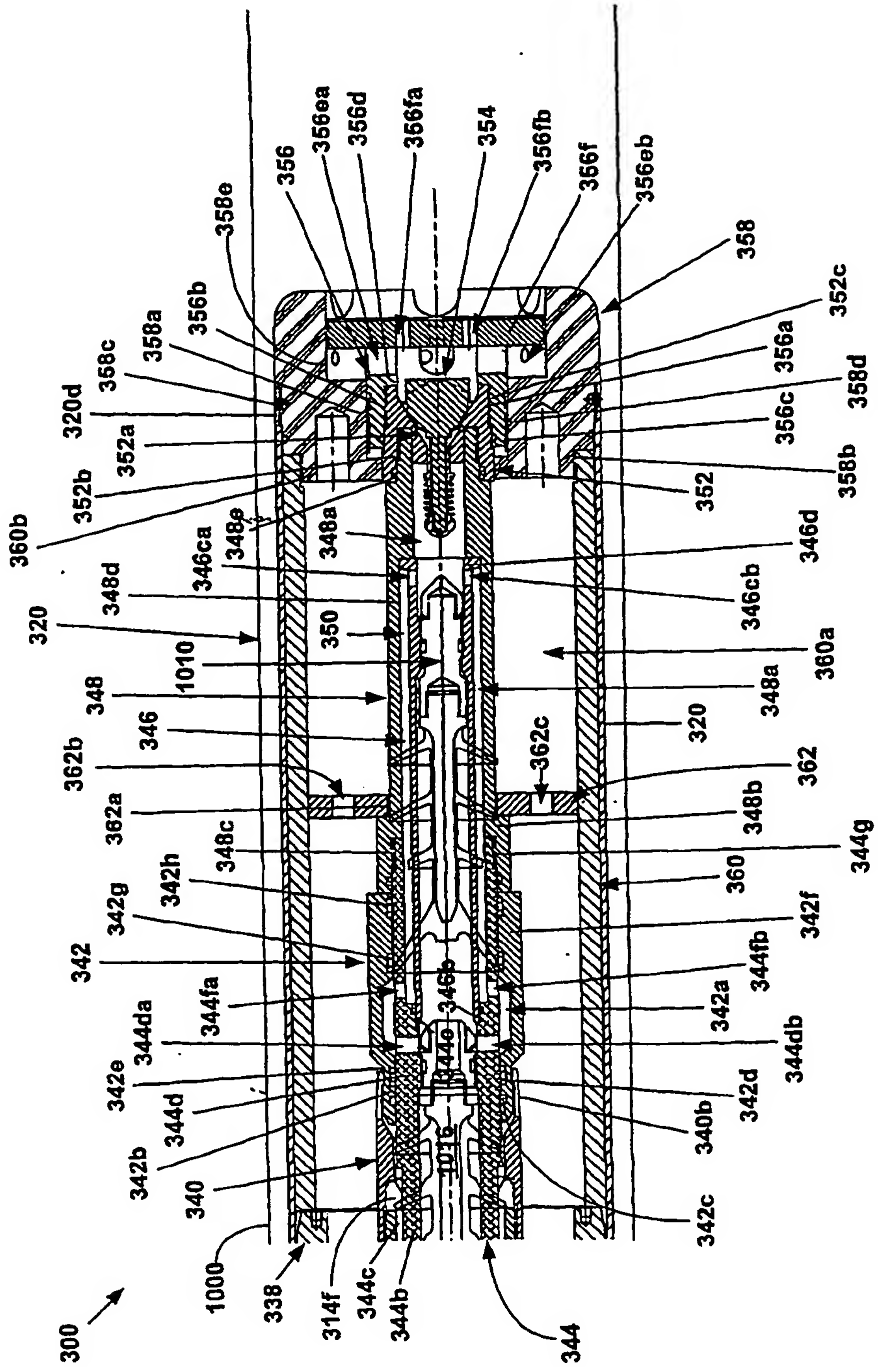

300
1000
338
314f
344c
344b
344
340
342b
344d
342e
344da
344fa
342
342g
342h
348c
362a
362b
346
348
1010
350
348d
346ca
348e
348a
360b
352b
352a
320d
358c
358a
356b
358e
356
356ea
356d
356fa
354
356fb
356f
356eb
358
352c
356a
358d
356c
358b
352
346d
346cb
360a
348a
320
362c
362
348b
344g
360
342f
344fb
342a
344db
342d
340b
342c
346b
344e
1016

Fig. 25c

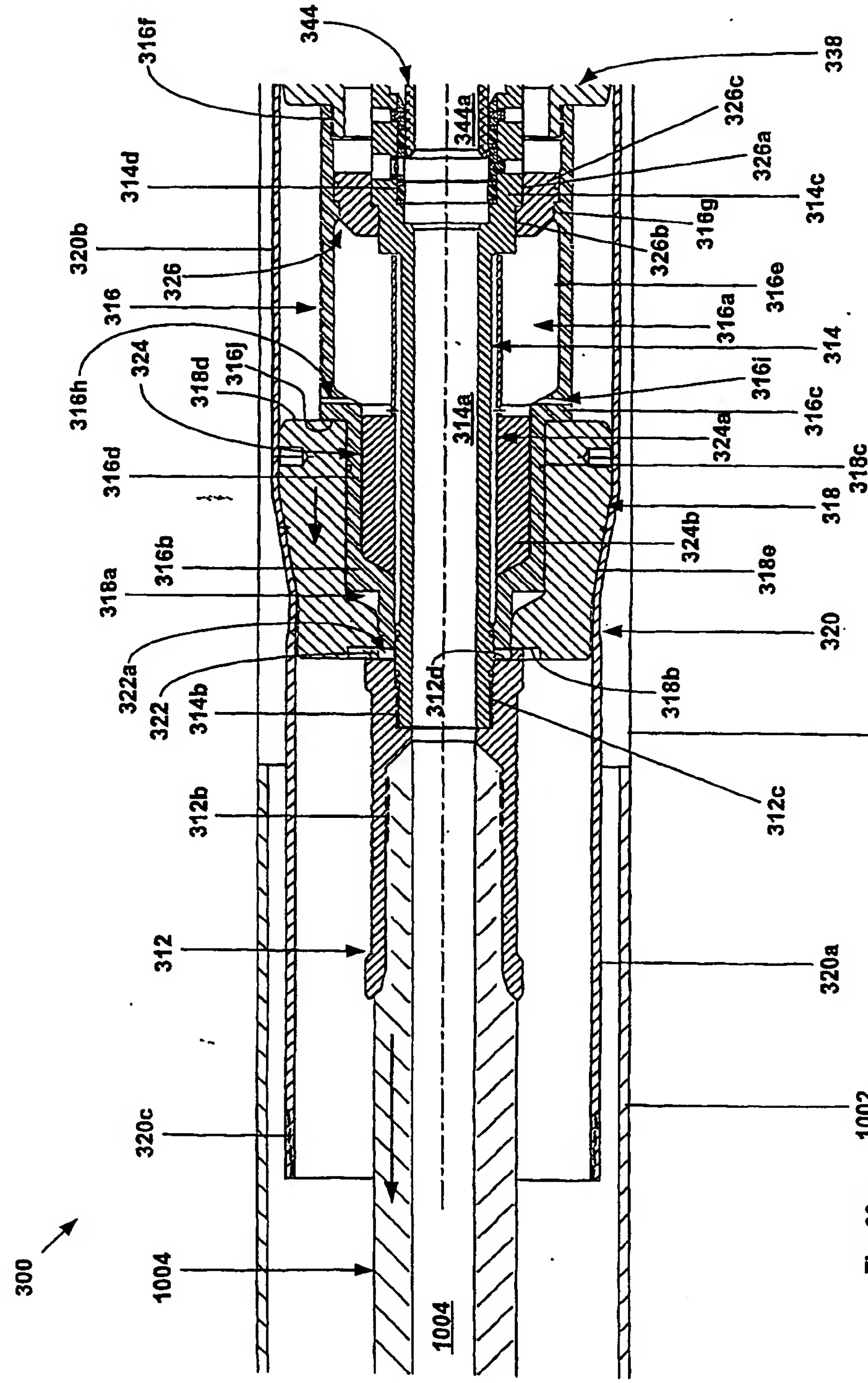
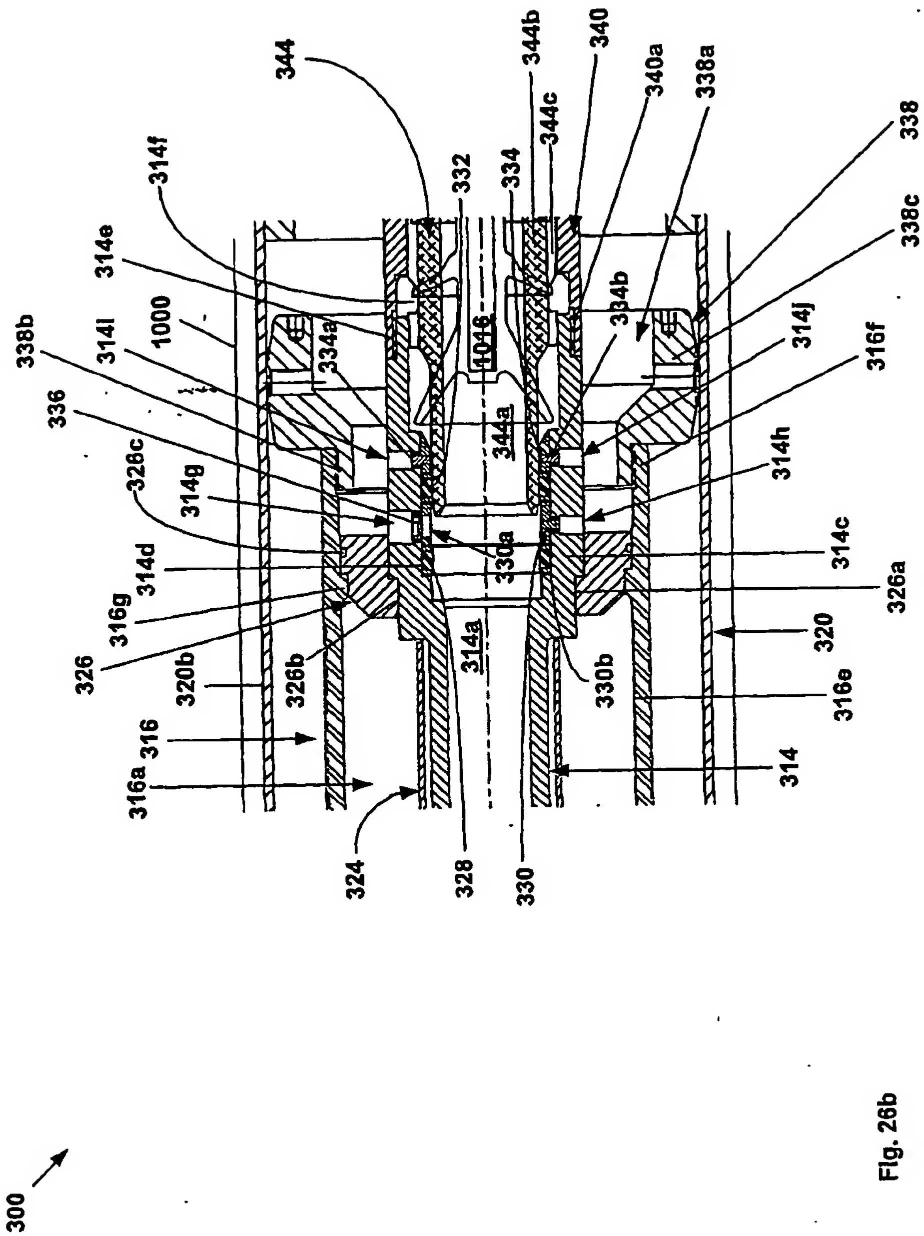

316f
344
338
344a
326c
326a
314d
314c
316g
320b
326b
326
316e
316
316a
314
316h
324
318d
316j
316i
314a
316c
324a
316d
318c
318
324b
316b
318a
318e
320
322a
318b
312d
322
314b
1000
312c
312b
312
320a
320c
1002
300
1004
1004

Fig. 26a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344
344b
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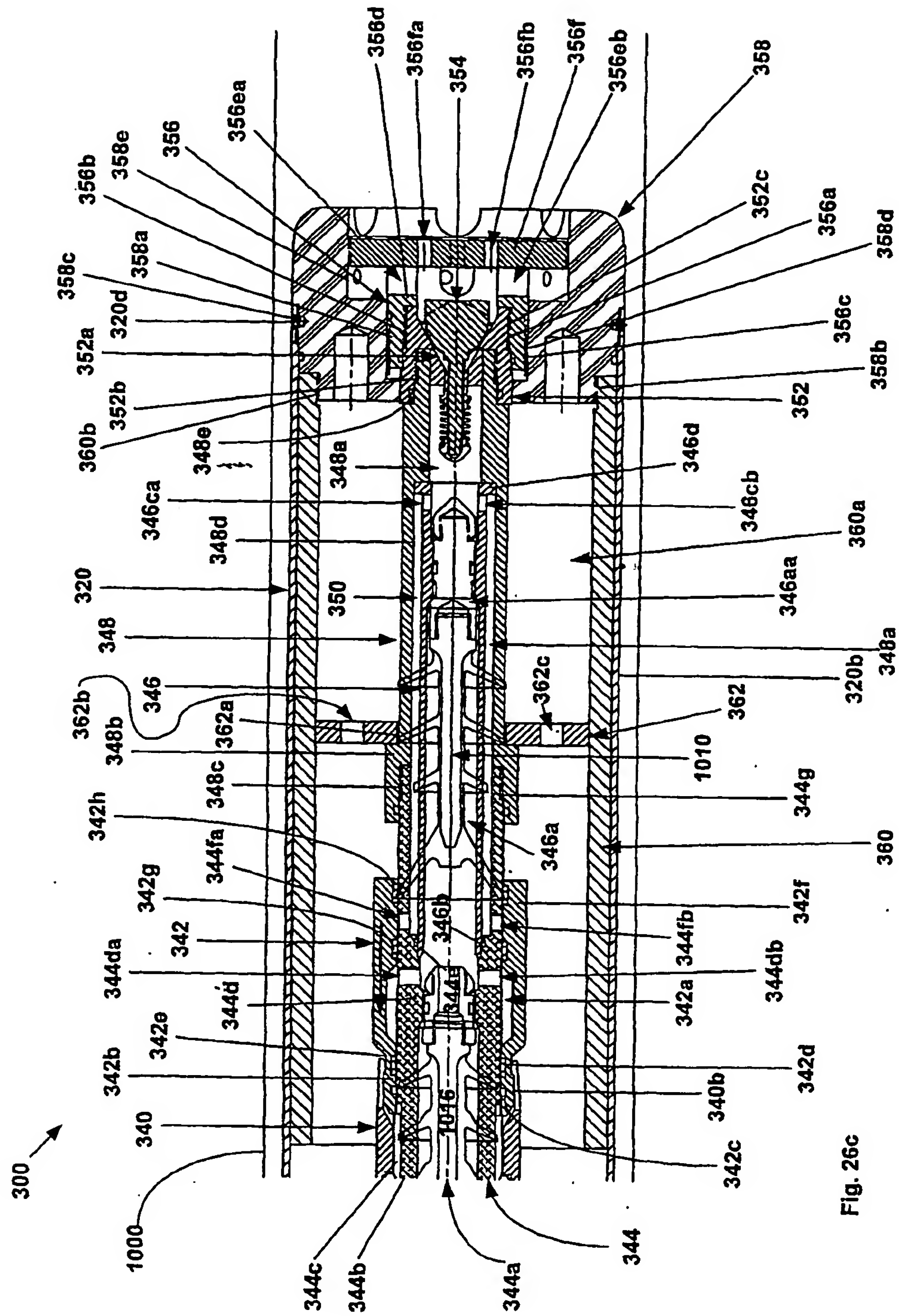
340a
338a
338
338c
332
334
344c
314f
314e
1000
1046
344a
334a
334b
314j
316f
338b
314l
336
328c
314g
314h
330a
314c
314d
316g
326a
326
314a
320b
326b
330b
320
316e
316
316a
314
324
328
330

Fig. 26b


300
1000
320
320d
320b
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340b
342
342a
342b
342c
342d
342e
342f
342g
342h
344
344a
344b
344c
344d
344da
344db
344fa
344fb
344g
346
346a
346b
346aa
346ca
346cb
346d
348
348a
348b
348c
348d
348e
350
352
352a
352b
352c
354
356
356a
356b
356c
356d
356ea
356eb
356f
356fa
356fb
358
358a
358b
358c
358d
358e
360
360a
360b
362
362a
362b
362c
1010
1016

Fig. 26c

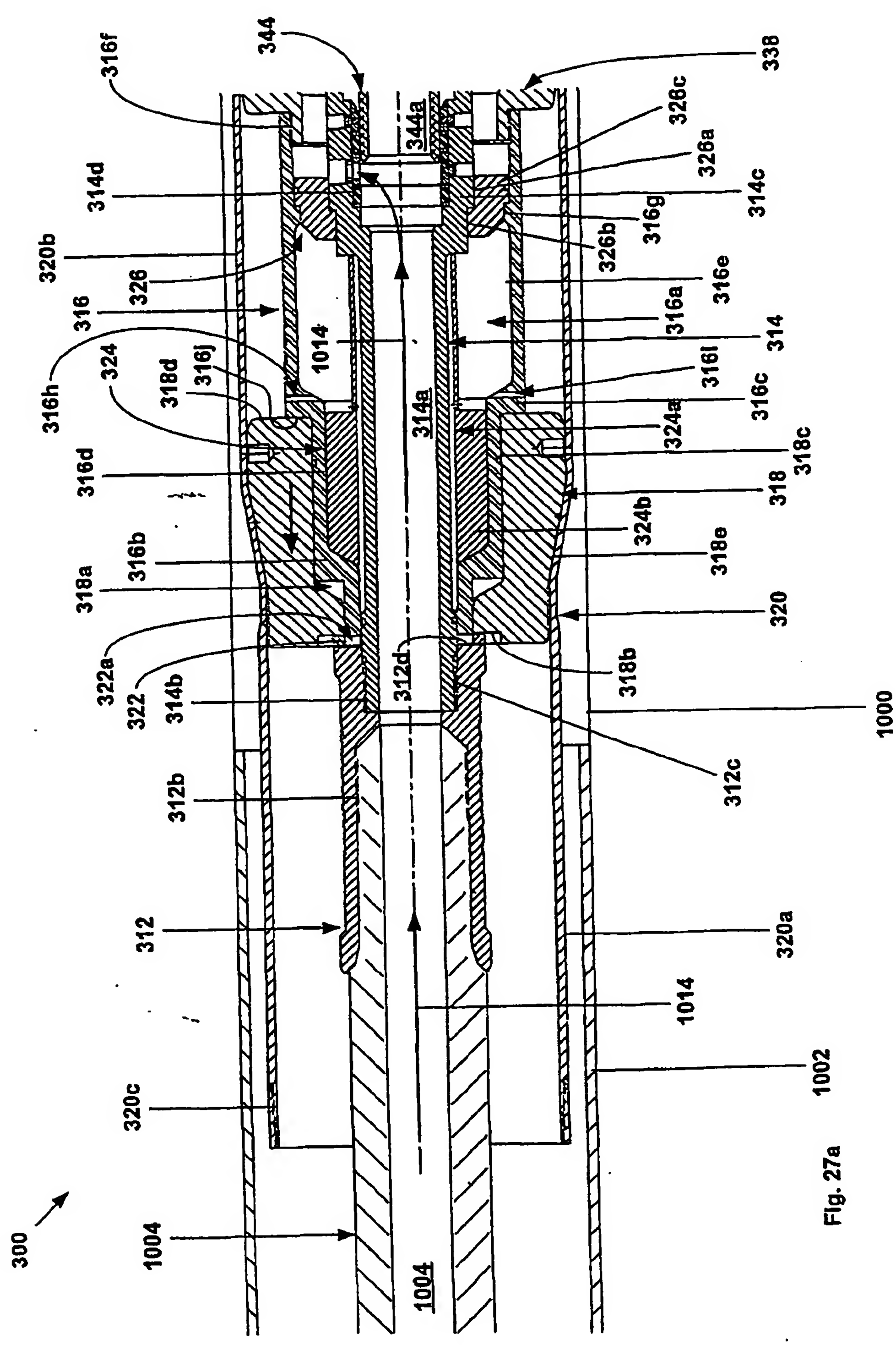
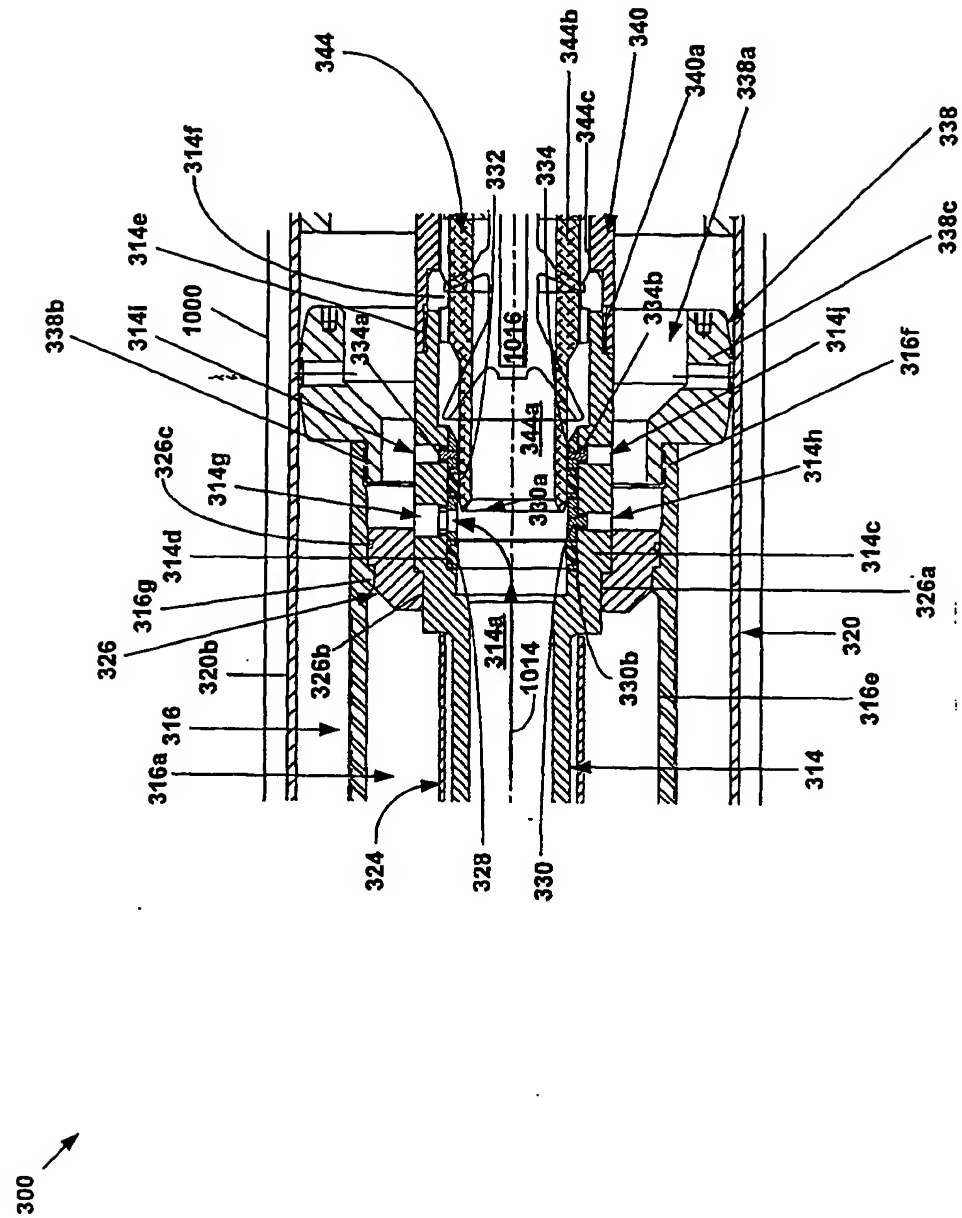

344
316f
338
344a
326c
326a
314d
314c
316g
326b
320b
326
316e
316
316a
1014
314
324
316h
318d
316j
316l
316c
314a
324a
318c
316d
318
324b
316b
318e
318a
320
322a
312d
318b
322
314b
1000
312c
312b
312
320a
1014
320c
1002
300
1004
1004

Fig. 27a


344
344b
340
340a
338a
338
338c
314f
332
334
344c
314e
1000
314i
338b
334a
1016
334b
314j
316f
344a
326c
314g
330a
314h
314d
314c
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316a
314
324
328
330
300

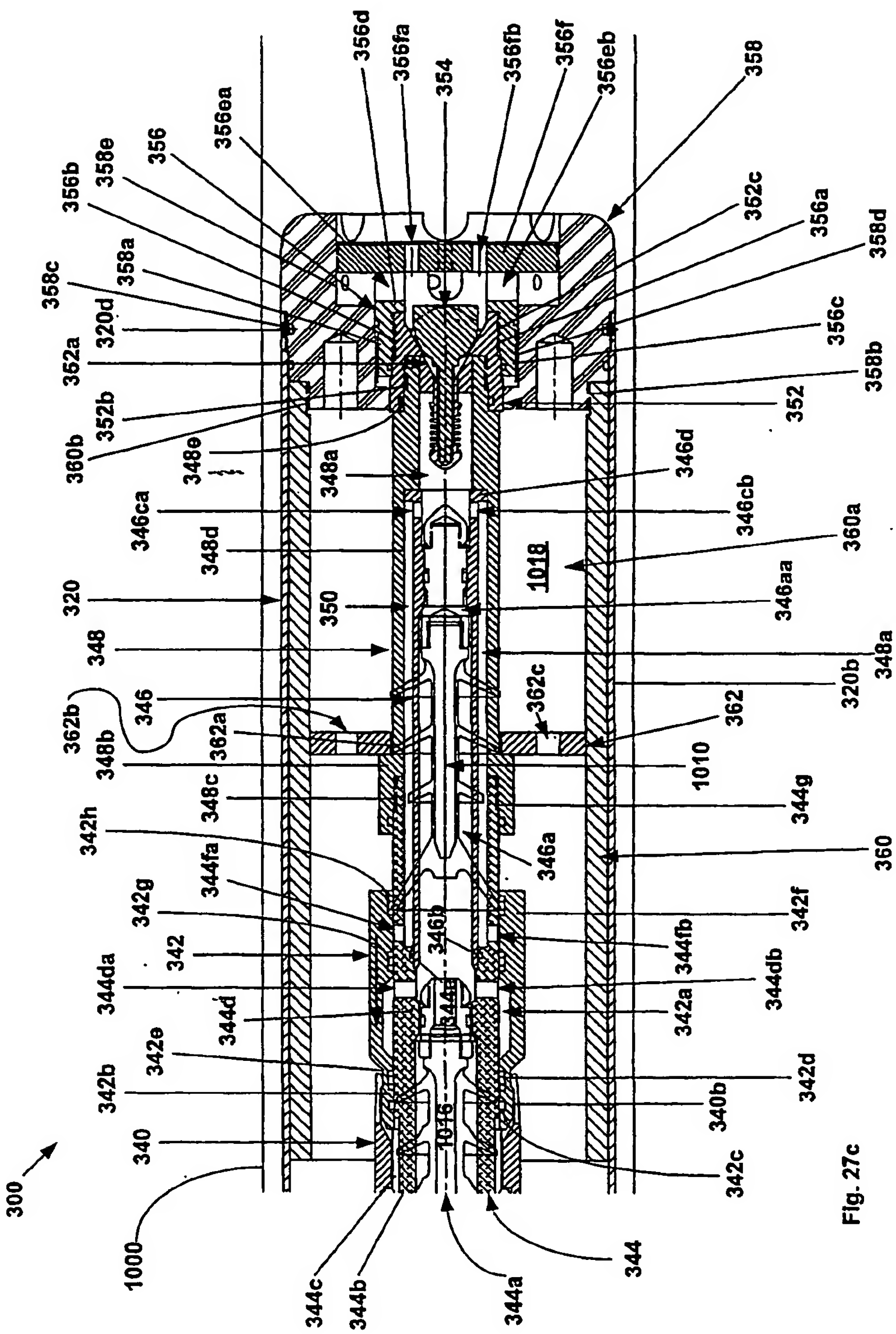


Fig. 27c

80/100

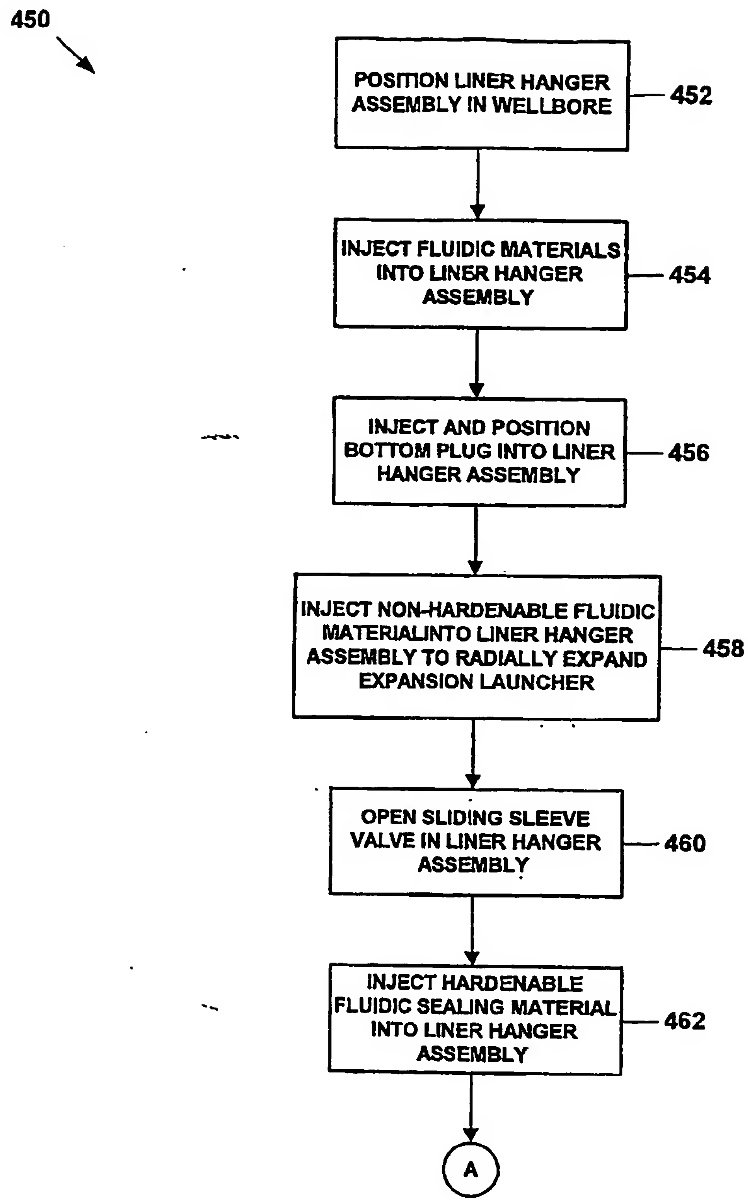

450
POSITION LINER HANGER ASSEMBLY IN WELLBORE
452
INJECT FLUIDIC MATERIALS INTO LINER HANGER ASSEMBLY
454
INJECT AND POSITION BOTTOM PLUG INTO LINER HANGER ASSEMBLY
456
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
458
OPEN SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
460
INJECT HARDENABLE FLUIDIC SEALING MATERIAL INTO LINER HANGER ASSEMBLY
462
A

Fig. 28a

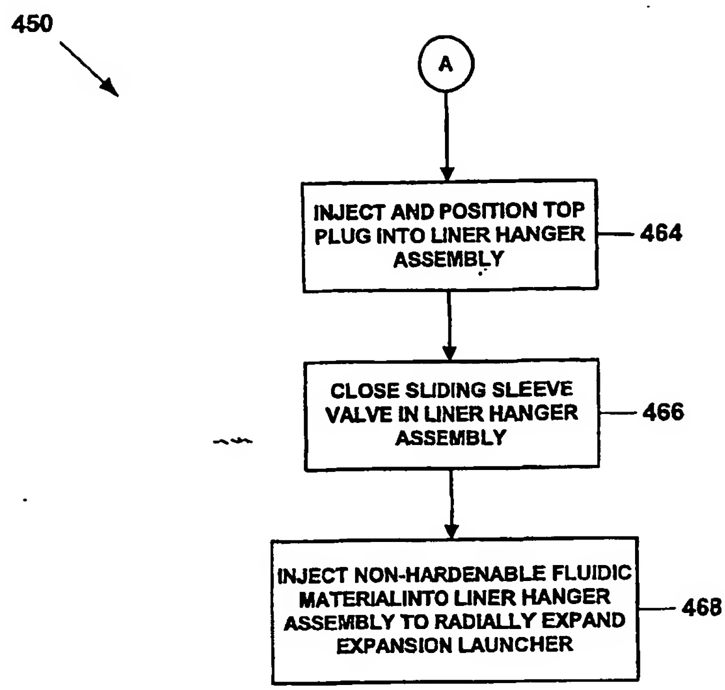

450
A
INJECT AND POSITION TOP PLUG INTO LINER HANGER ASSEMBLY
464
CLOSE SLIDING SLEEVE VALVE IN LINER HANGER ASSEMBLY
466
INJECT NON-HARDENABLE FLUIDIC MATERIALINTO LINER HANGER ASSEMBLY TO RADIALLY EXPAND EXPANSION LAUNCHER
468

Fig. 28b

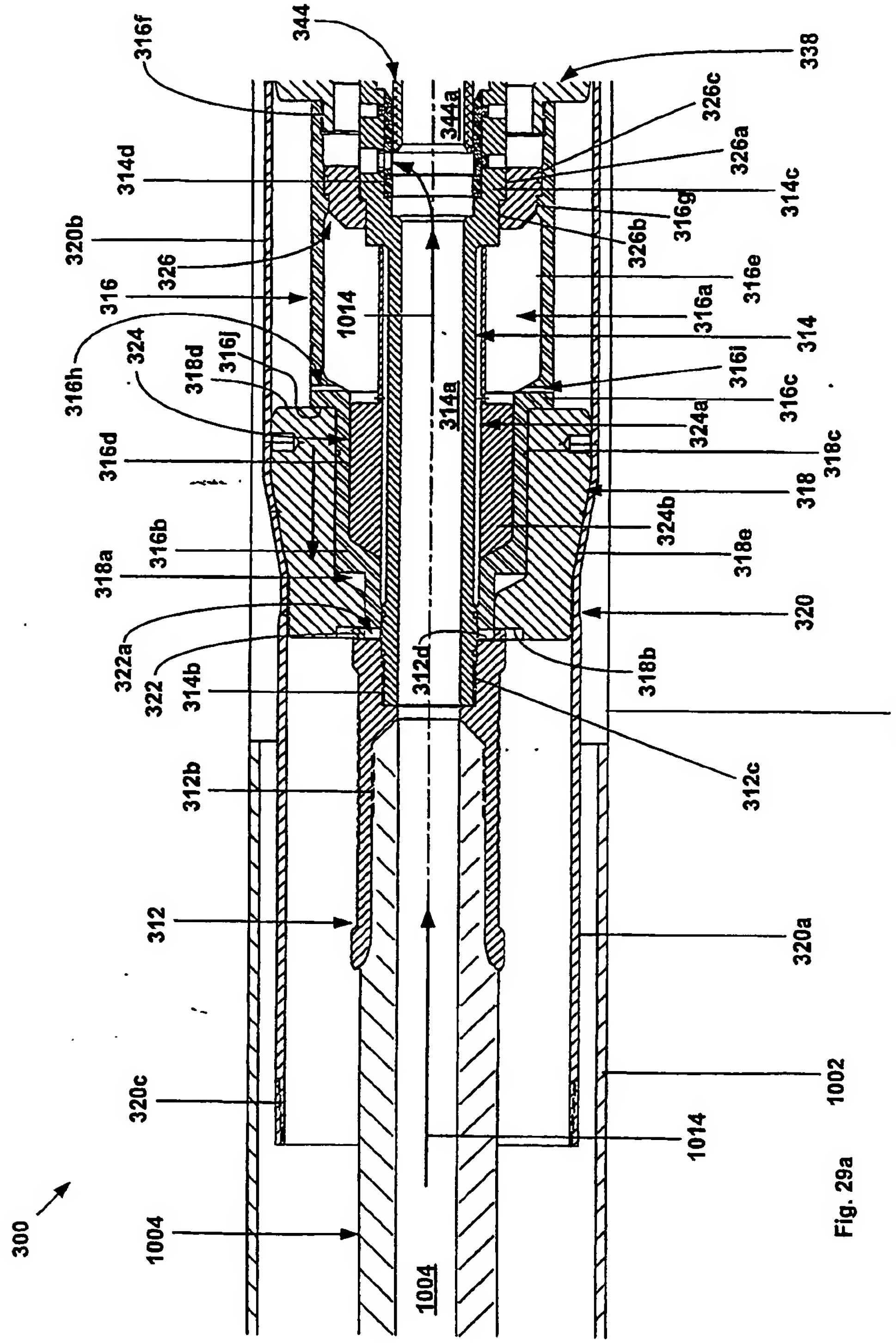
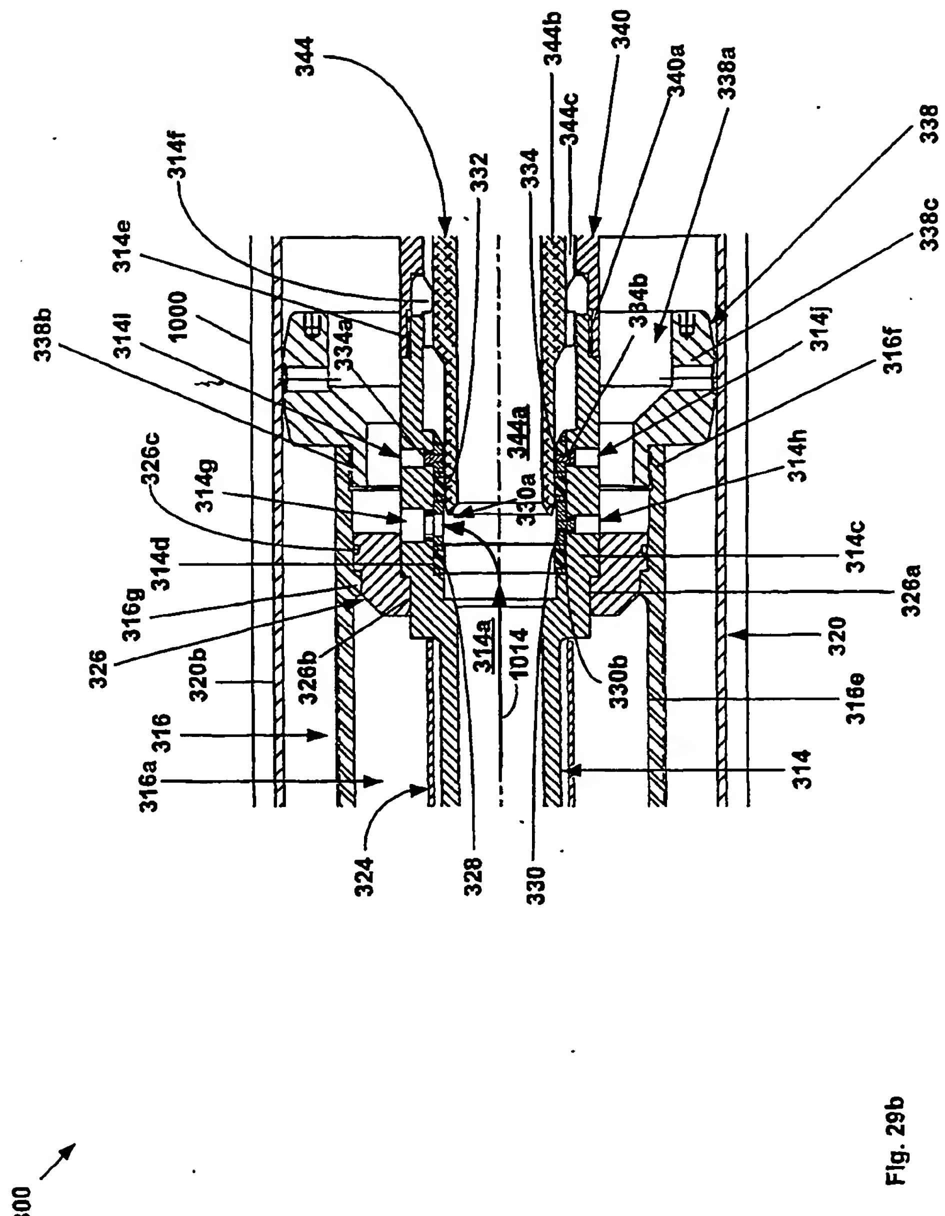

344
344a
338
316f
326c
326a
314d
314c
316g
320b
326b
326
316e
316
1014
316a
314
316h
324
318d
316j
316i
316c
314a
324a
316d
318c
318
324b
316b
318e
318a
320
322a
322
312d
318b
314b
1000
312c
312b
312
320a
320c
1002
1014
300
1004
1004

Fig. 29a


300
344
344b
340
340a
338a
338
338c
314f
332
334
344c
314e
1000
338b
314l
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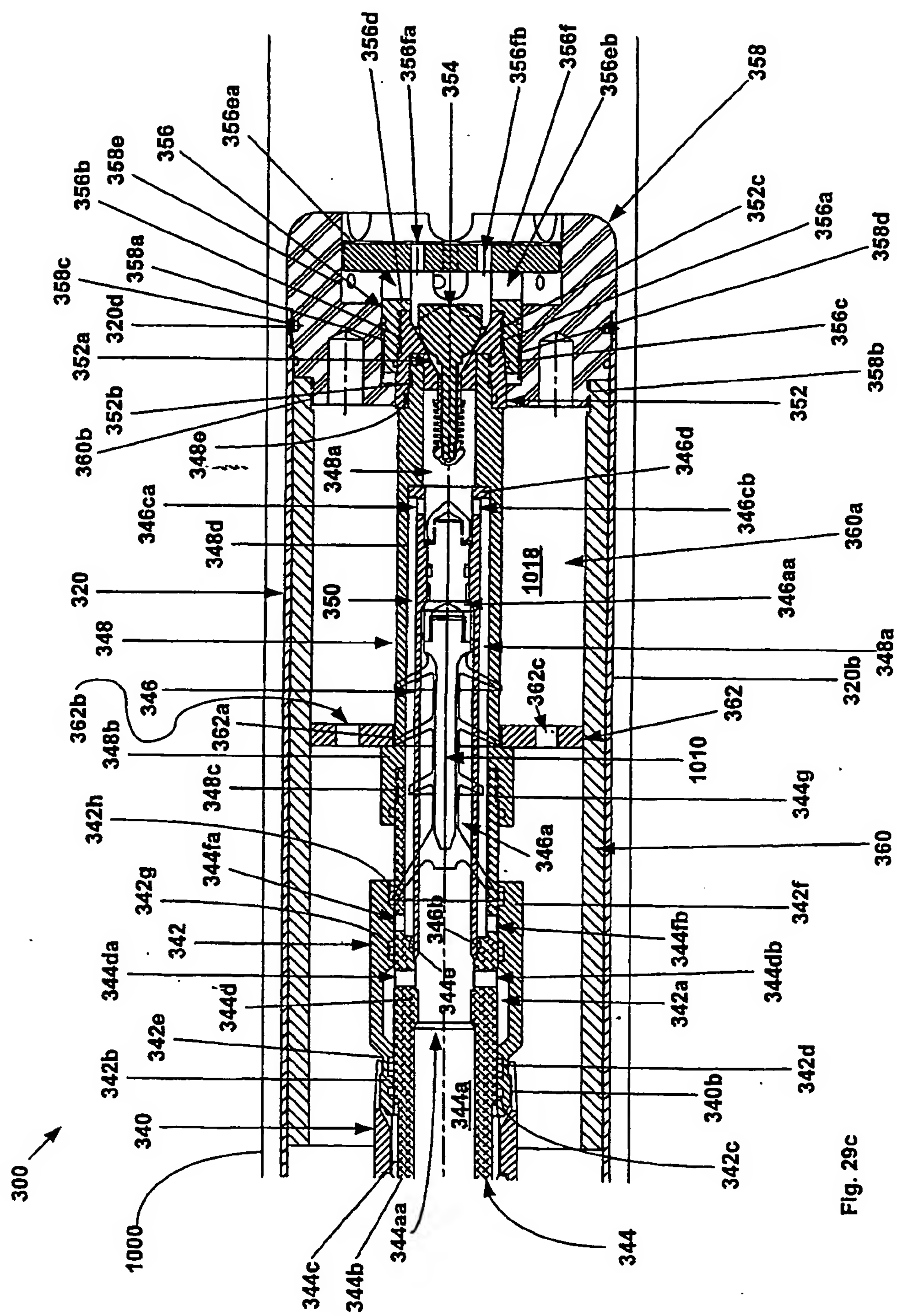
334b
314j
316f
344a
326c
314g
330a
314h
314c
314d
326a
316g
320
326
320b
326b
314a
1014
330b
316e
316
316a
314
324
328
330

Fig. 29b


356d
356fa
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356fb
356f
356eb
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356ea
356
358e
356b
352c
356a
358d
358a
358c
320d
356c
352a
358b
352b
352
360b
348e
348a
346d
346ca
346cb
348d
1018
360a
320
350
346aa
348
348a
320b
362c
346
362b
362a
362
348b
1010
348c
344g
342h
346a
360
344fa
342g
342f
342
346b
344fb
344da
344e
344db
344d
342a
342e
342b
342d
340b
340
344a
342c
300
1000
344c
344b
344aa
344

Fig. 29c

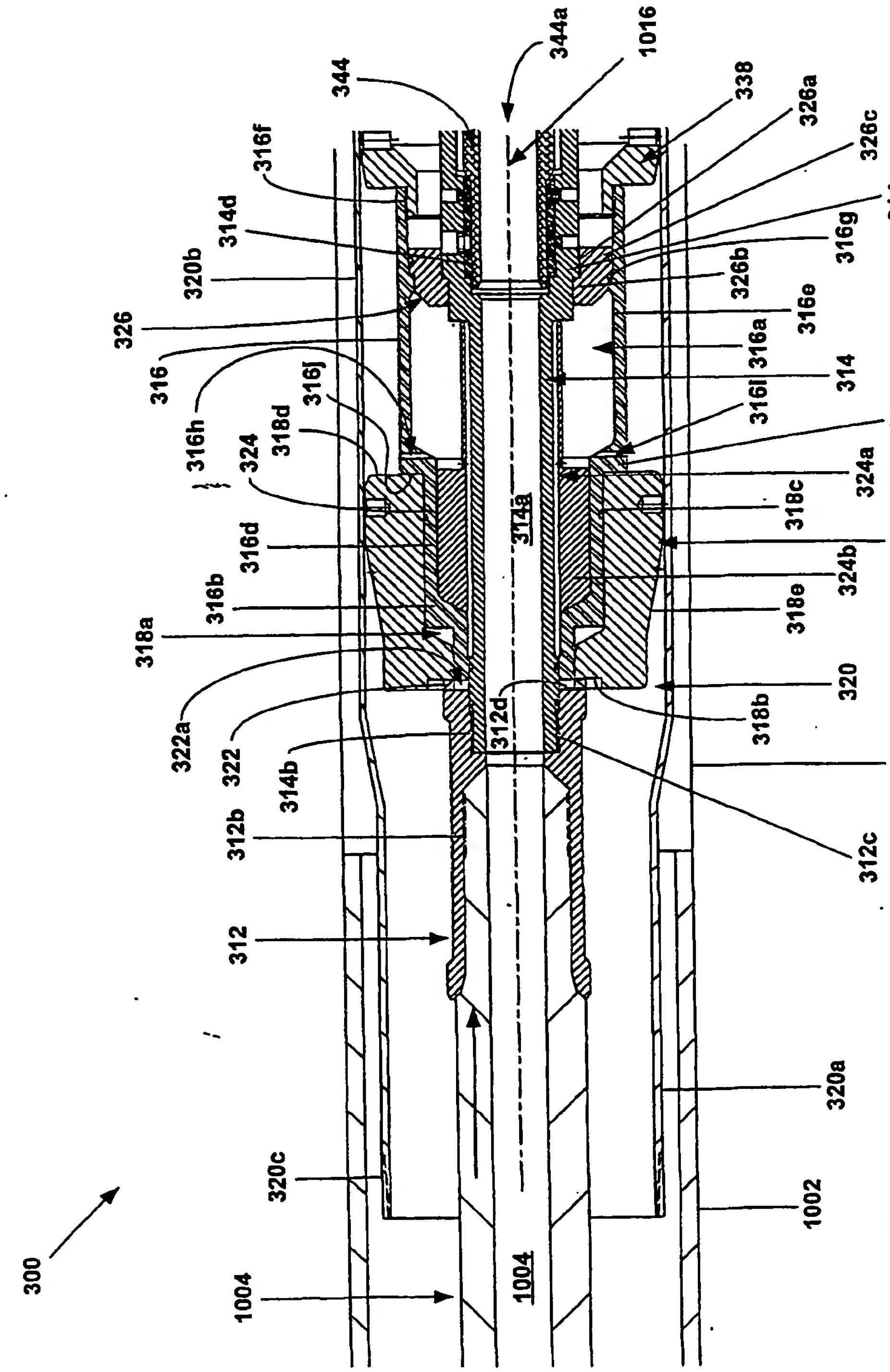

300
344
344a
1016
338
326a
326c
314c
316f
316g
314d
320b
326b
326
316e
316a
316
314
316j
316i
318d
316c
316h
324
324a
318c
316d
318
324b
316b
318e
318a
320
322a
312d
318b
322
314a
314b
1000
312b
312c
312
320a
320c
1002
1004

Fig. 30a

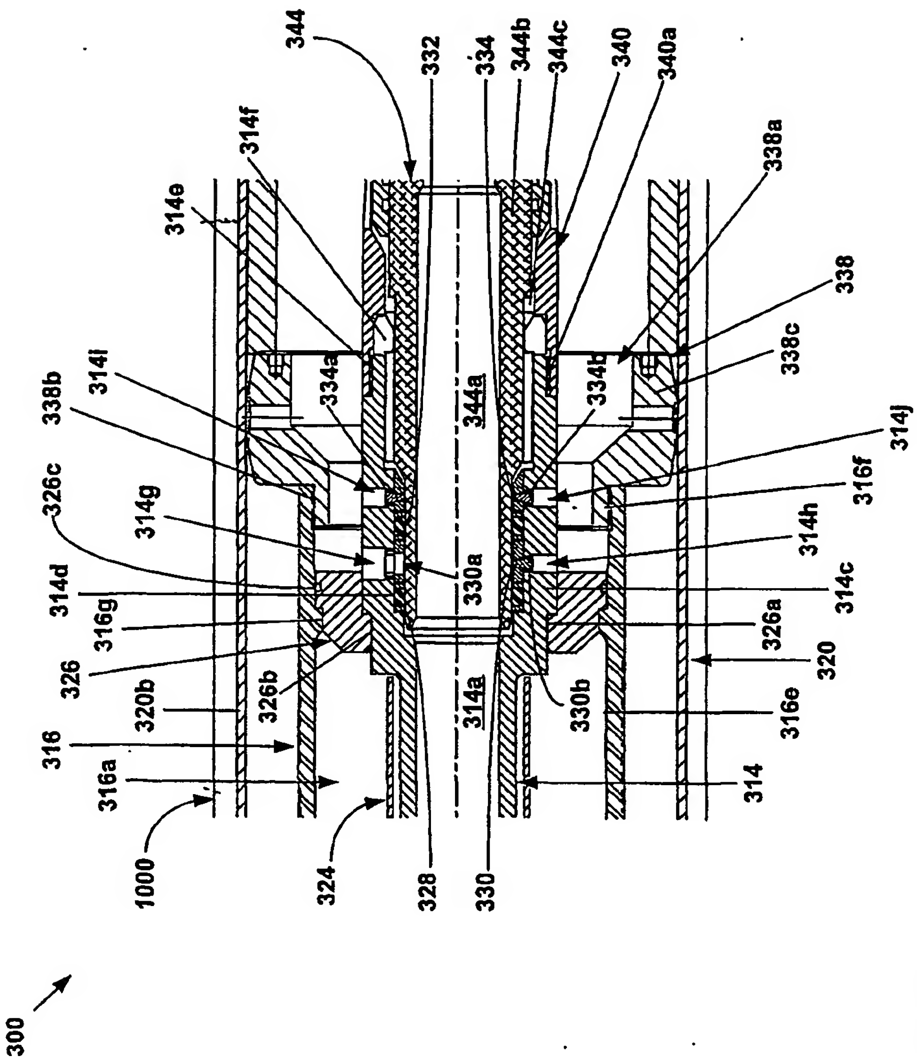

300
1000
324
328
330
316a
316
320b
326b
326
316g
314d
326c
314g
330a
338b
314l
334a
344a
314a
314e
314f
344
332
334
344b
344c
340
340a
338a
338
338c
334b
314j
316f
314h
314c
326a
330b
320
316e
314

Fig. 30b

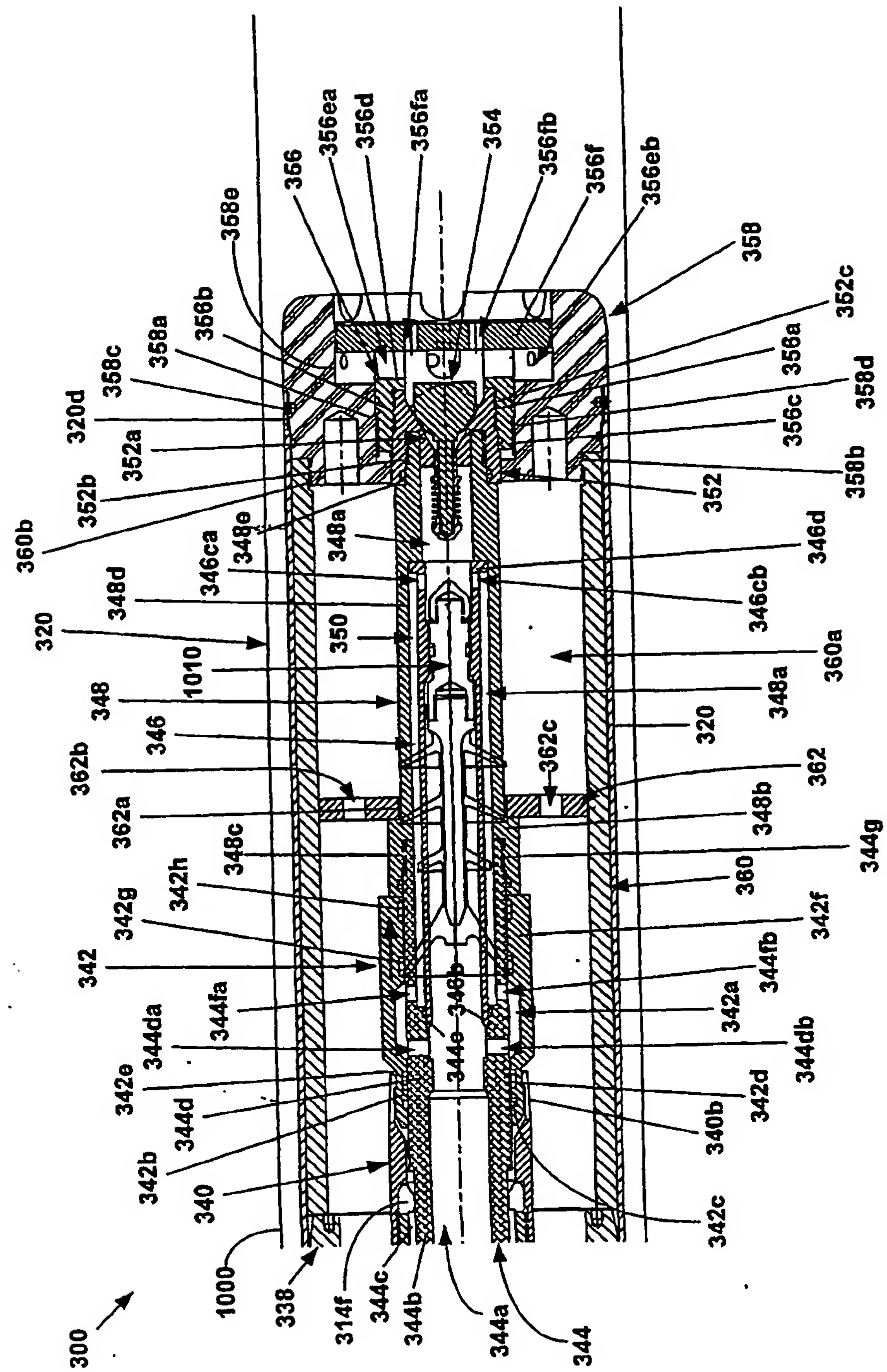
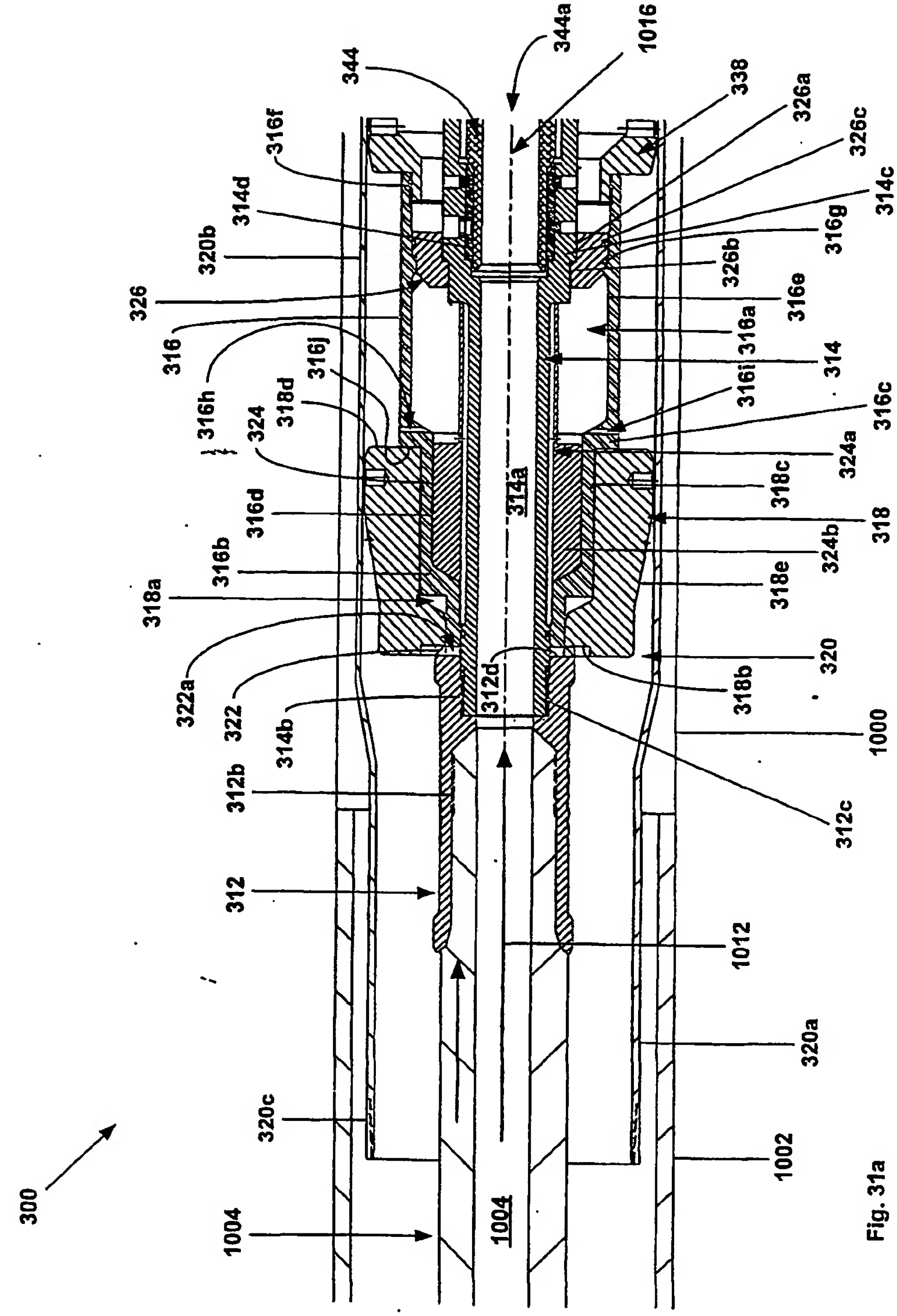

300
1000
338
314f
344c
344b
344a
344
340
342b
344d
342e
344da
344fa
342
342g
342h
348c
362a
362b
346
348
1010
320
350
348d
346ca
348e
348a
360b
352b
352a
320d
358c
358a
356b
358e
356
356ea
356d
356fa
354
356fb
356f
356eb
358
352c
356a
358d
356c
358b
352
346d
346cb
360a
348a
320
362c
362
348b
344g
360
342f
344fb
346b
344e
342a
344db
342d
340b
342c

Fig. 30c


344
344a
1016
338
326a
326c
314c
316g
316f
314d
320b
326b
316e
326
316a
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314
316j
316h
316i
318d
316c
324
324a
318c
314a
316d
318
324b
316b
318e
318a
320
312d
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Fig. 31a

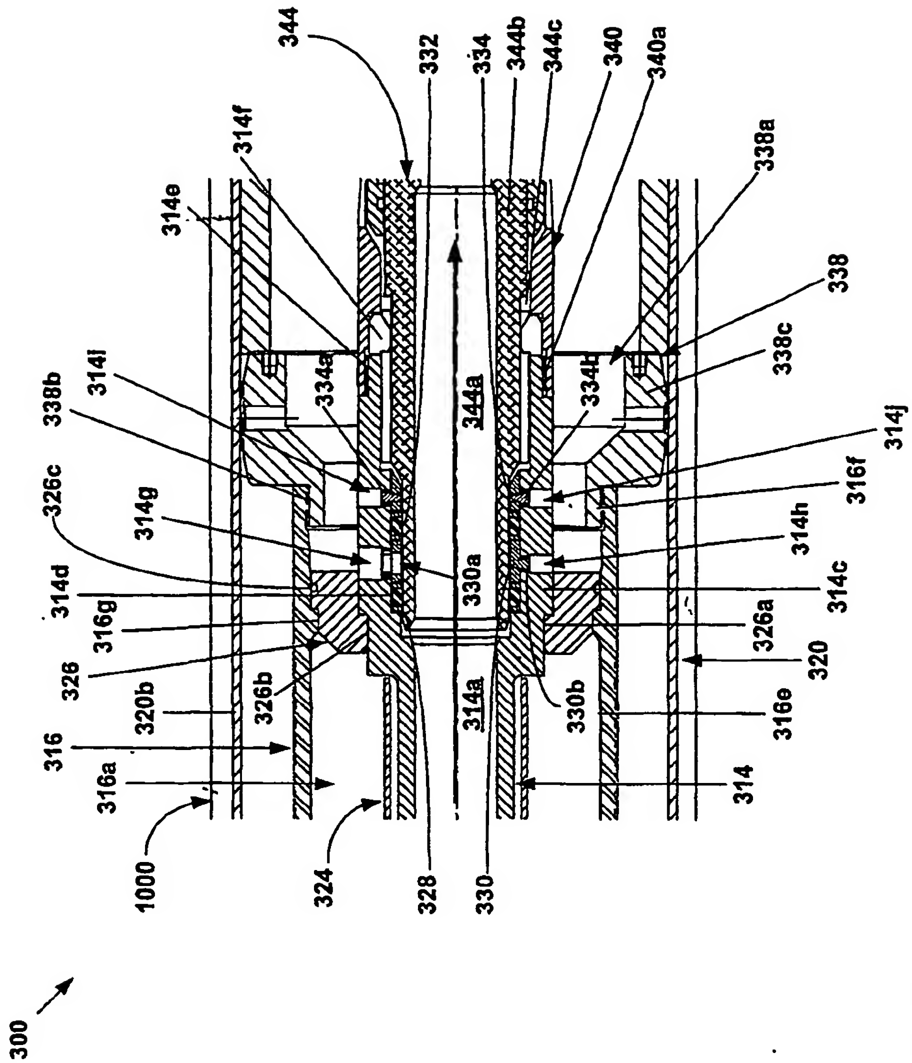
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Fig. 31b

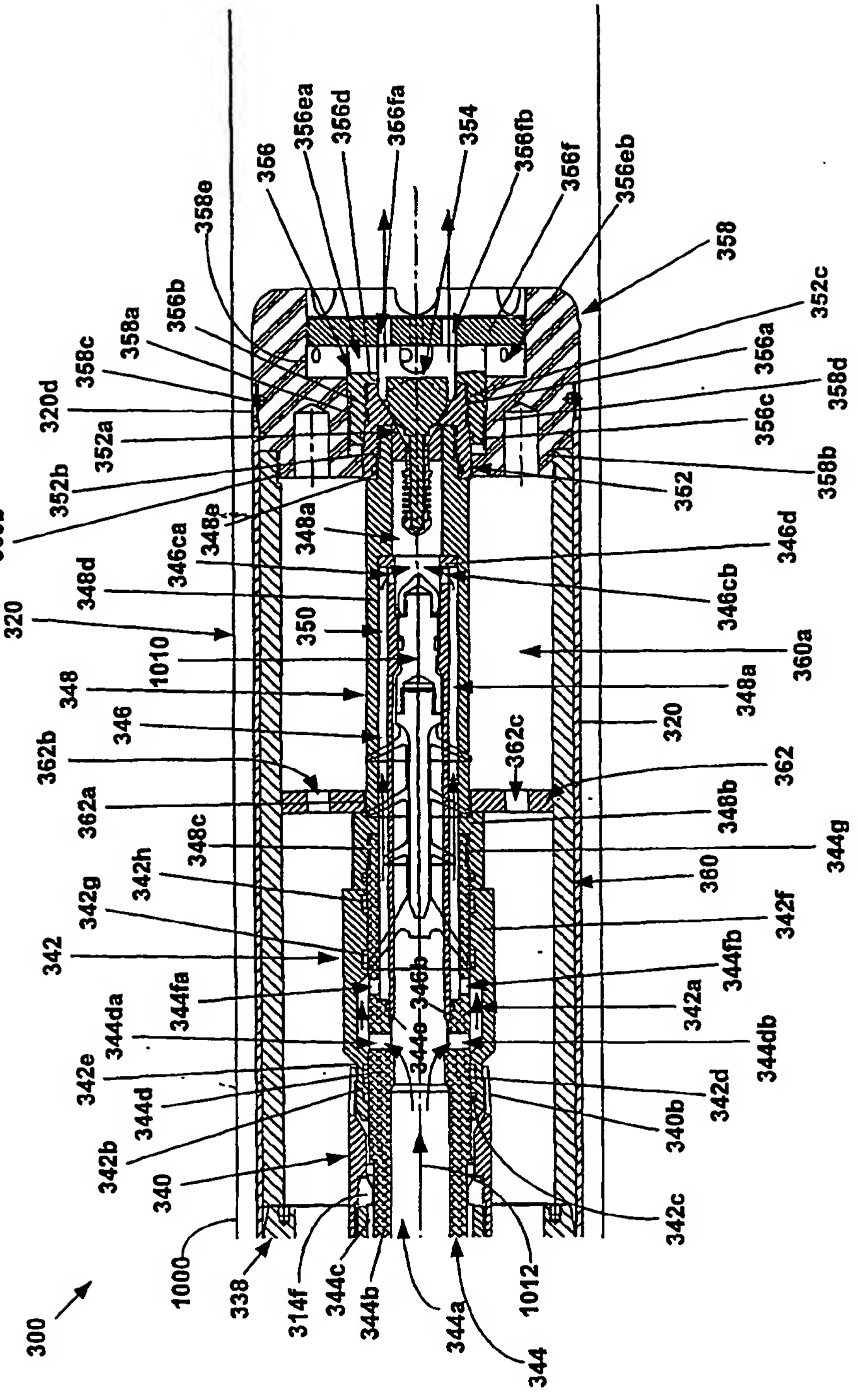
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Fig. 31c

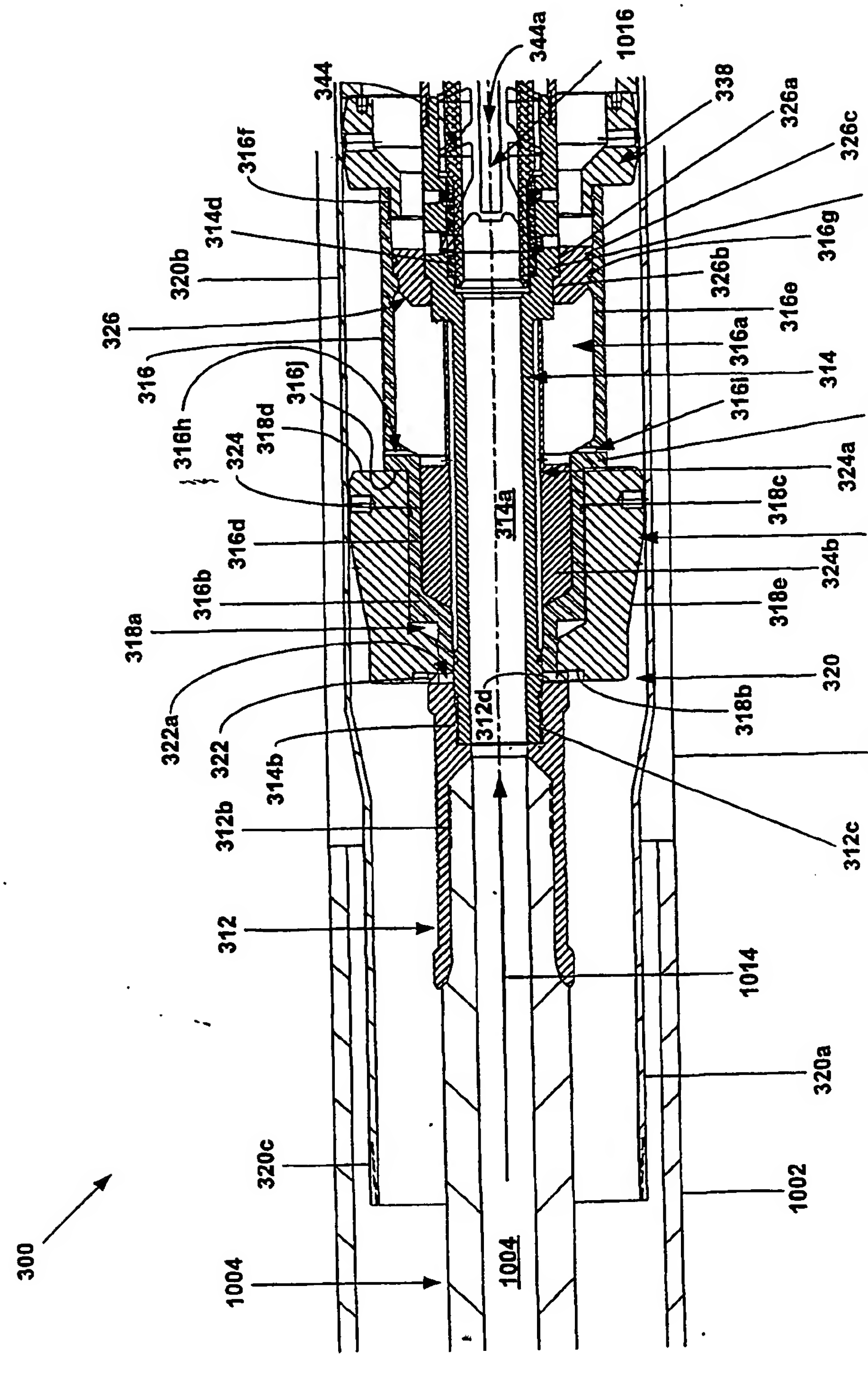
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Fig. 32a

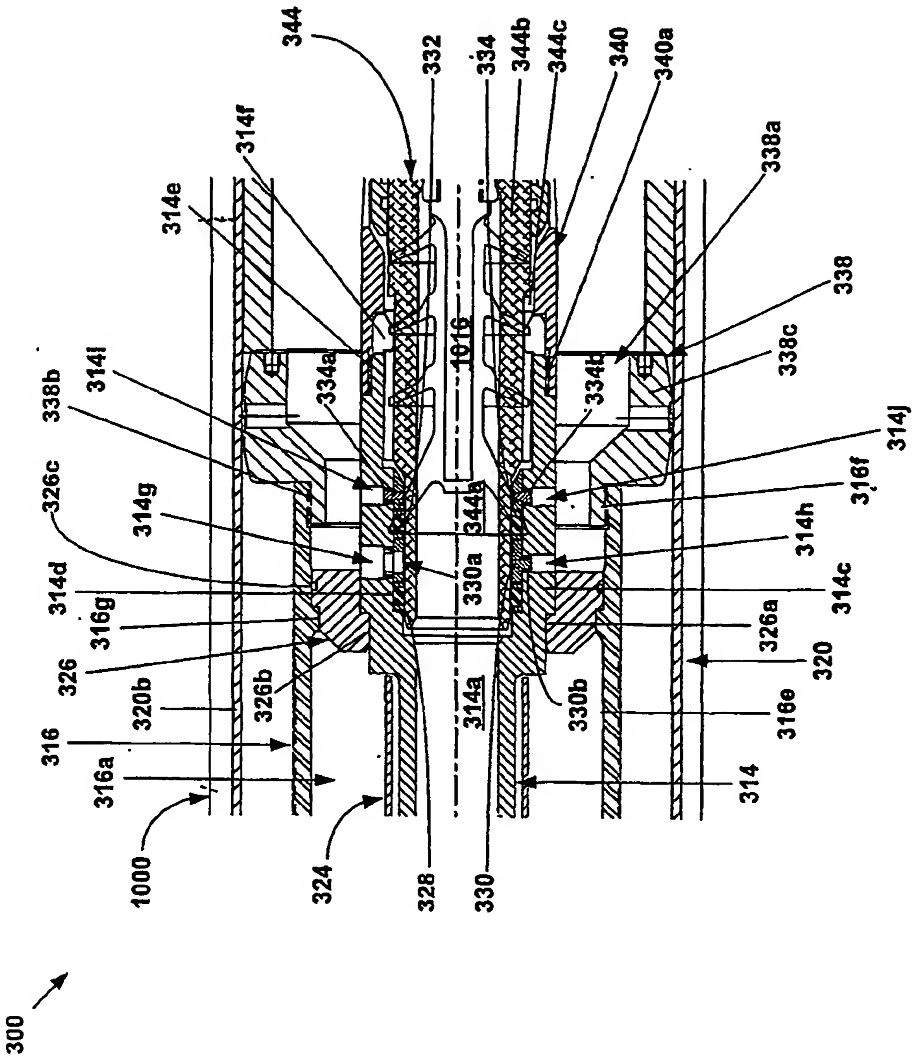
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Fig. 32b

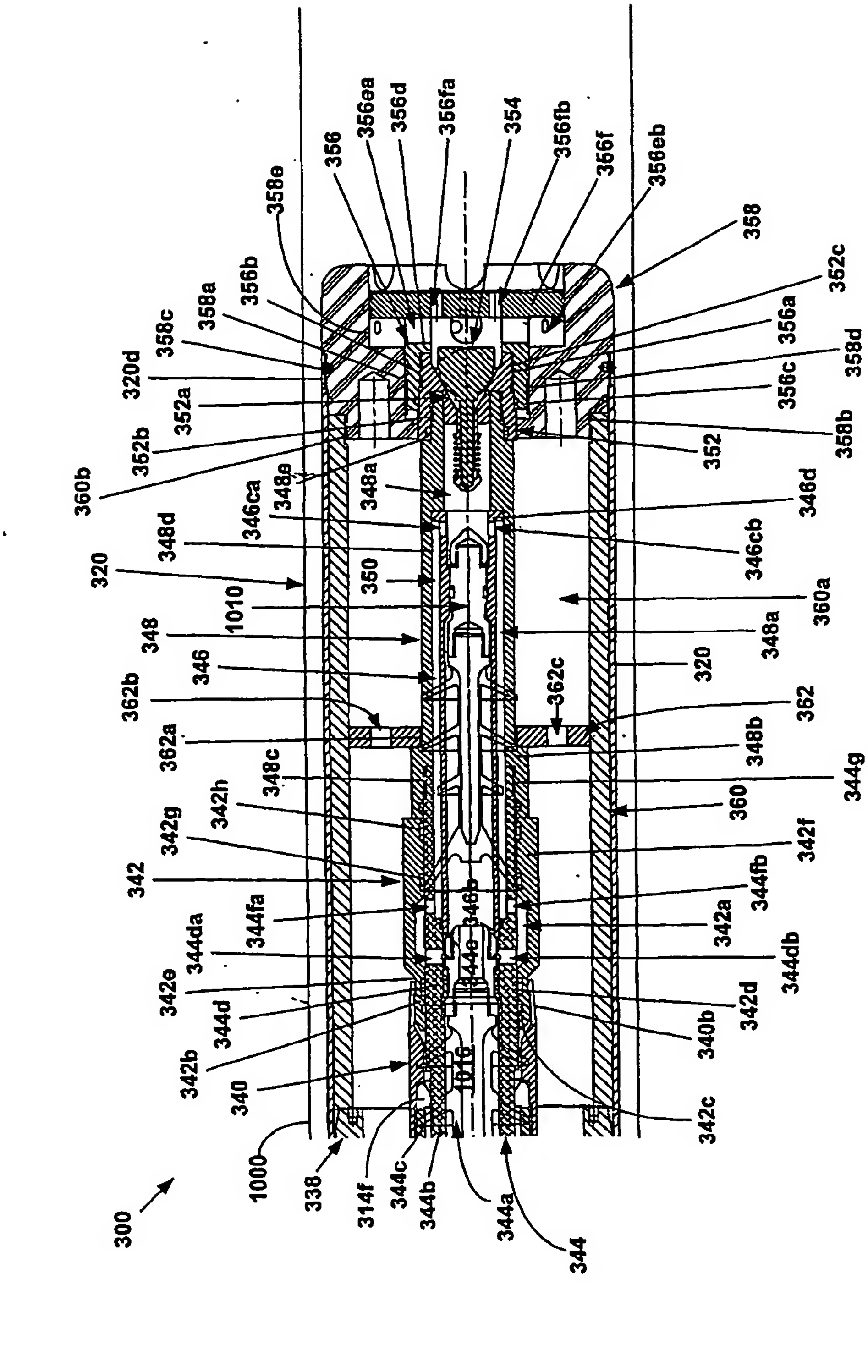
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Fig. 32c

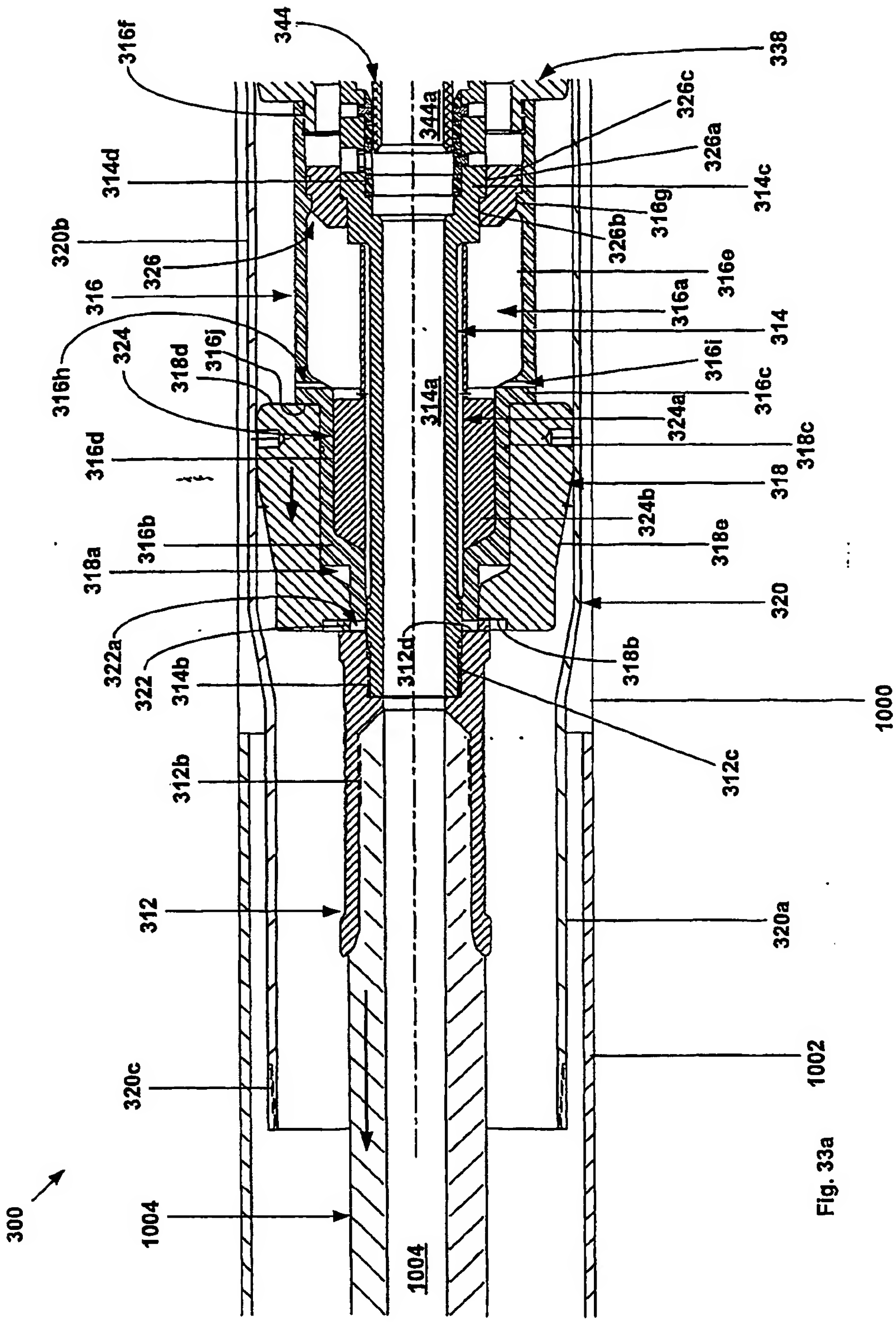
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Fig. 33a

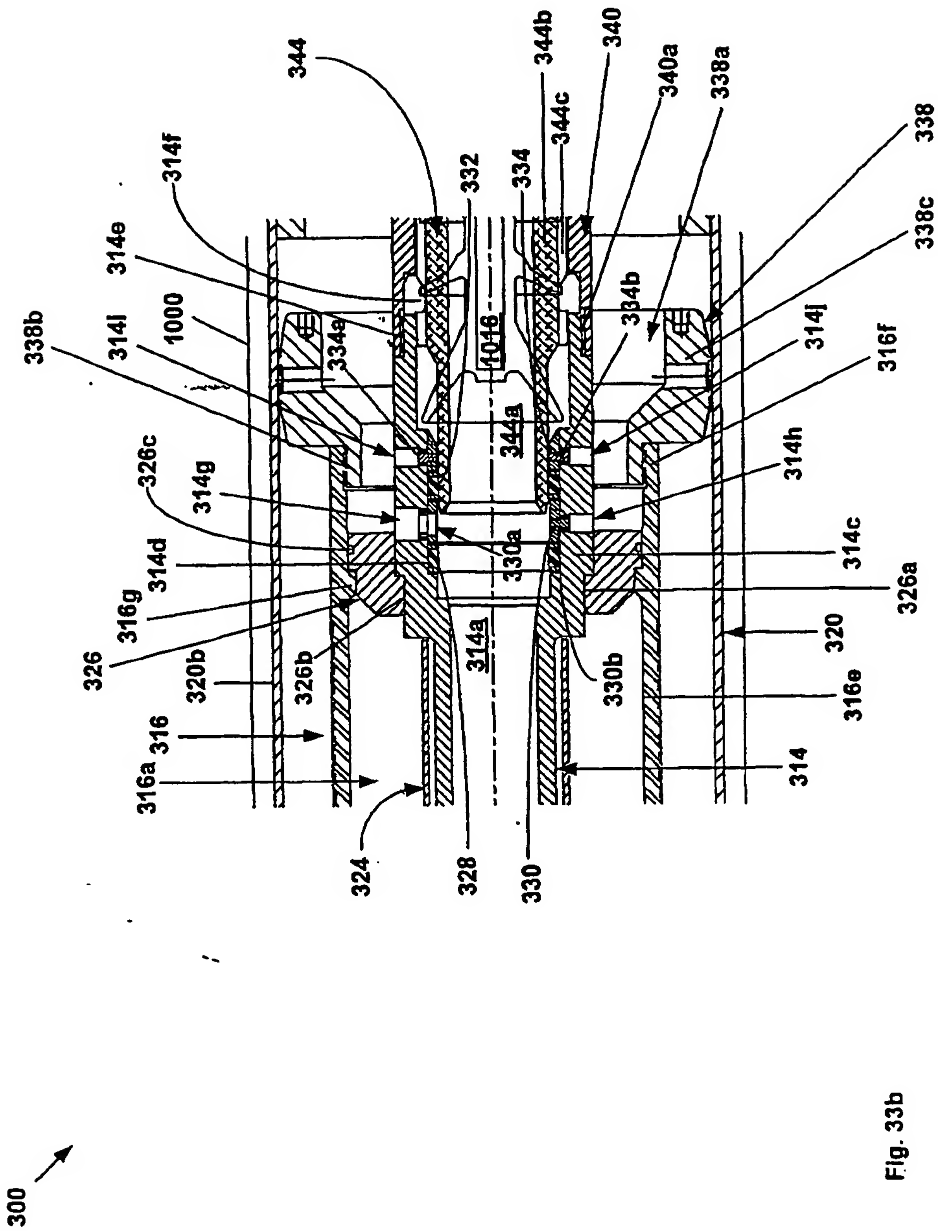
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Fig. 33b

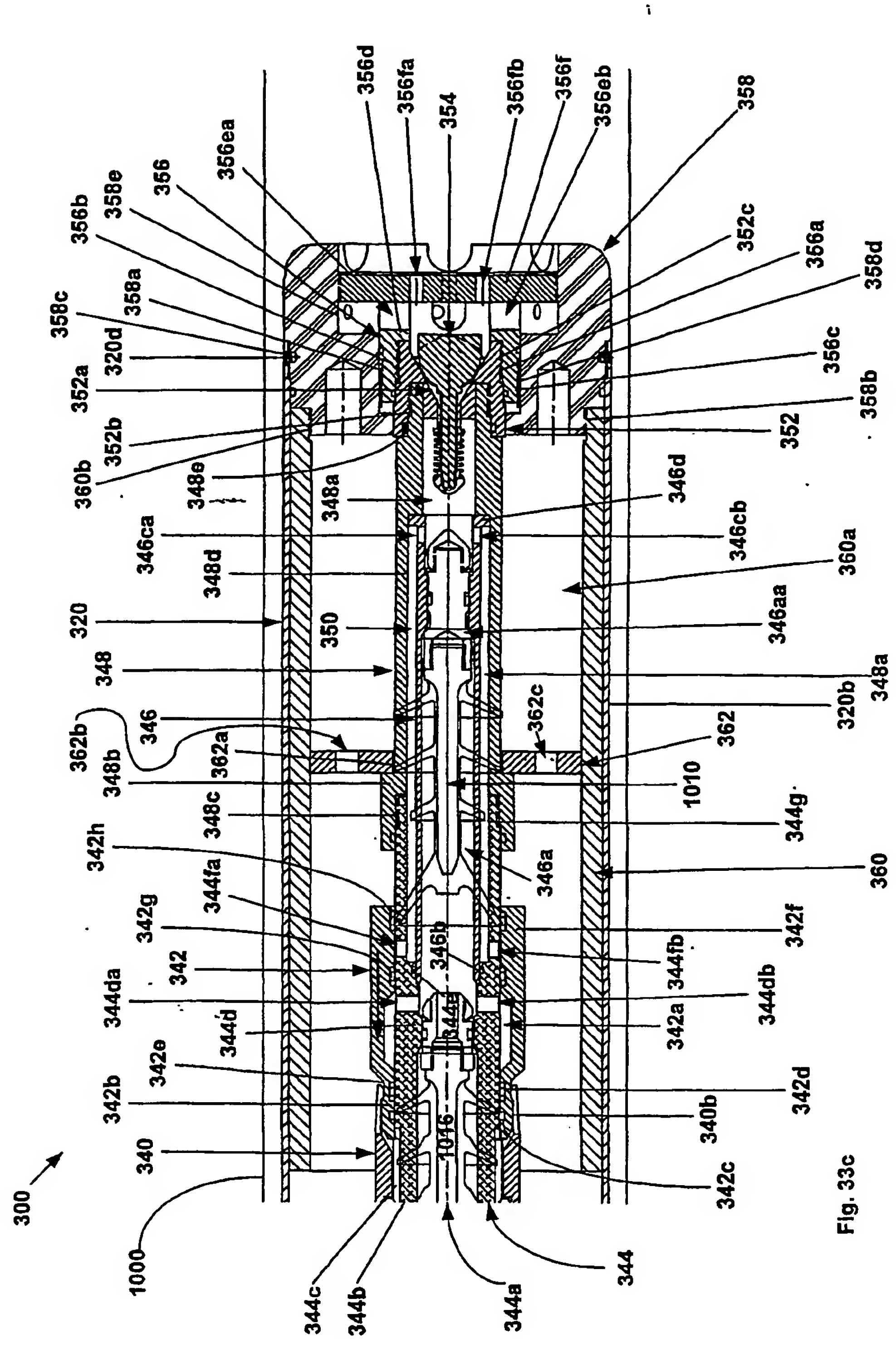
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Fig. 33c

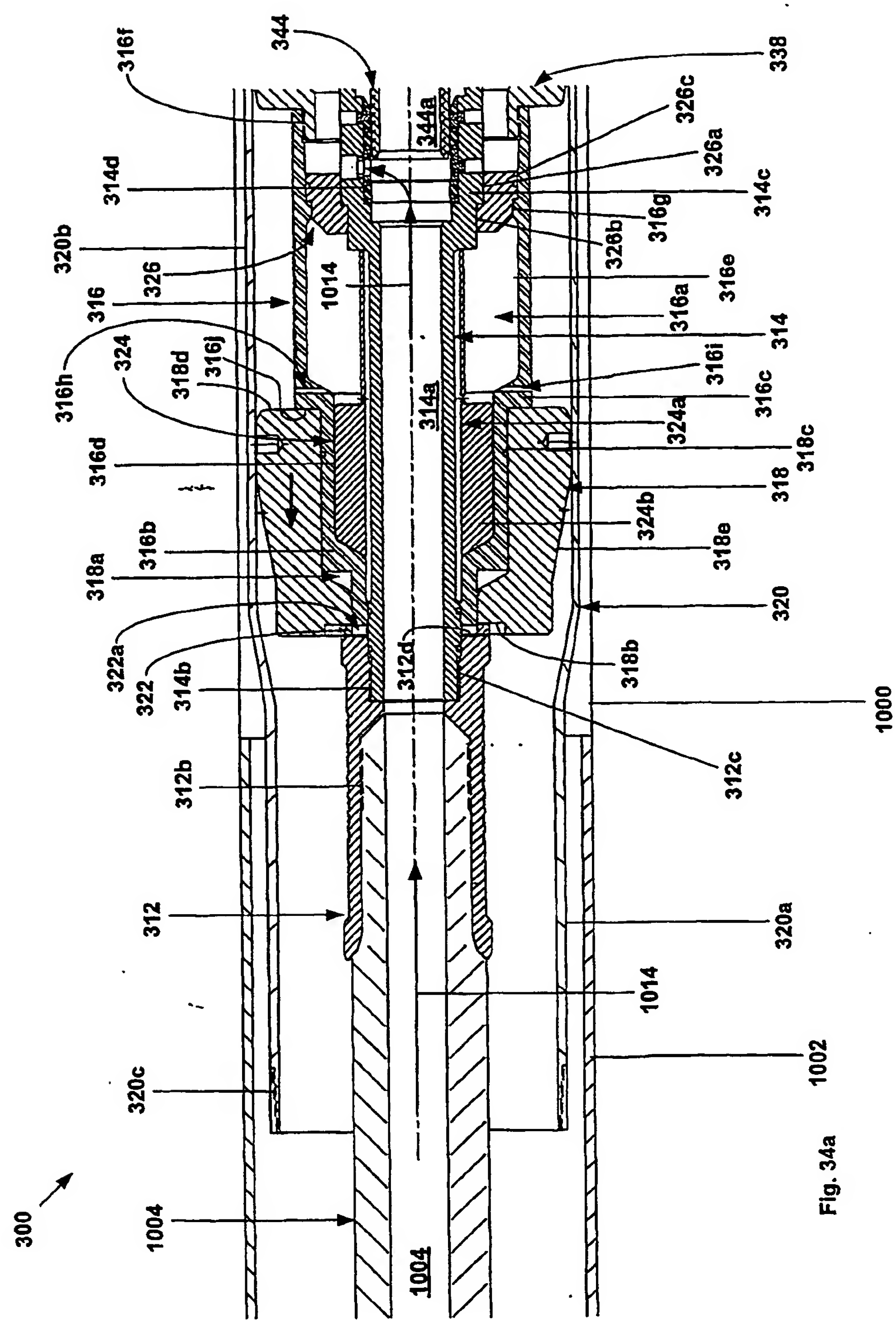
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Fig. 34a

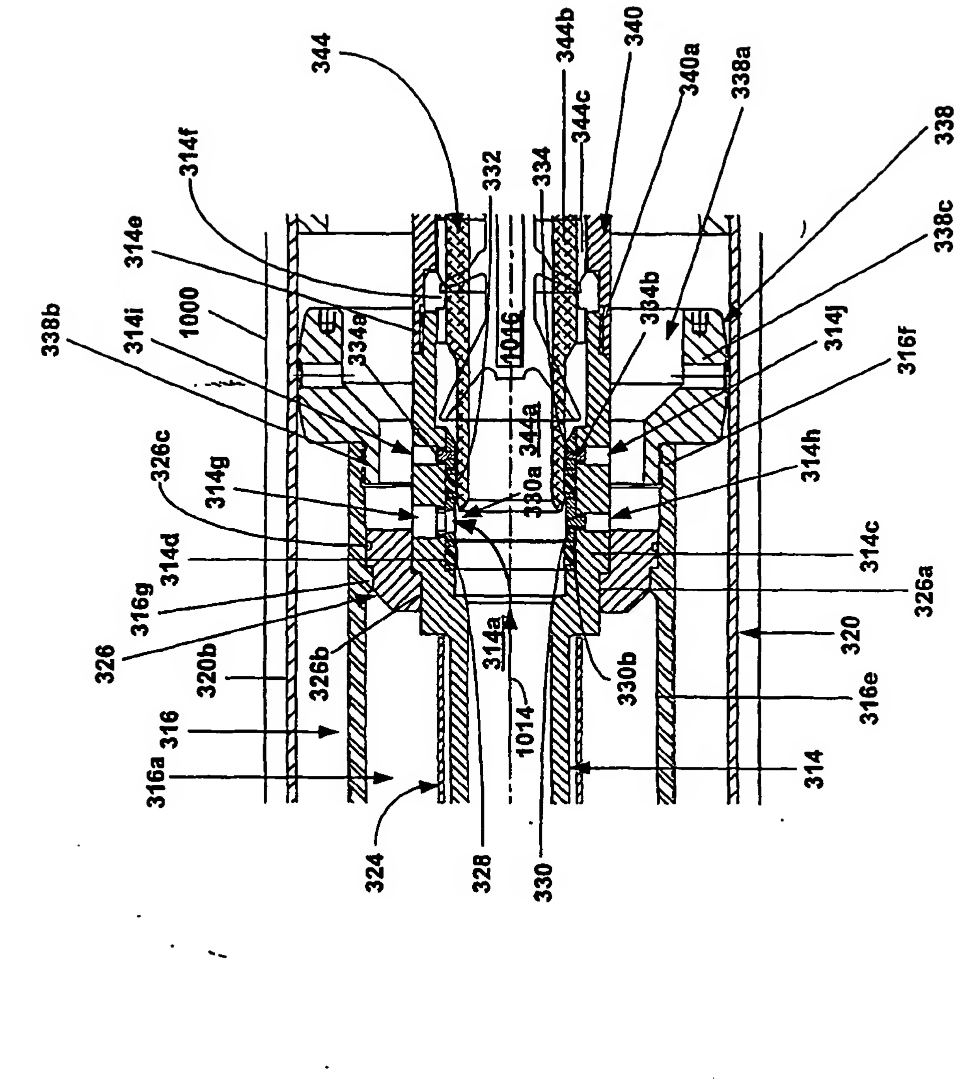
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Fig. 34b

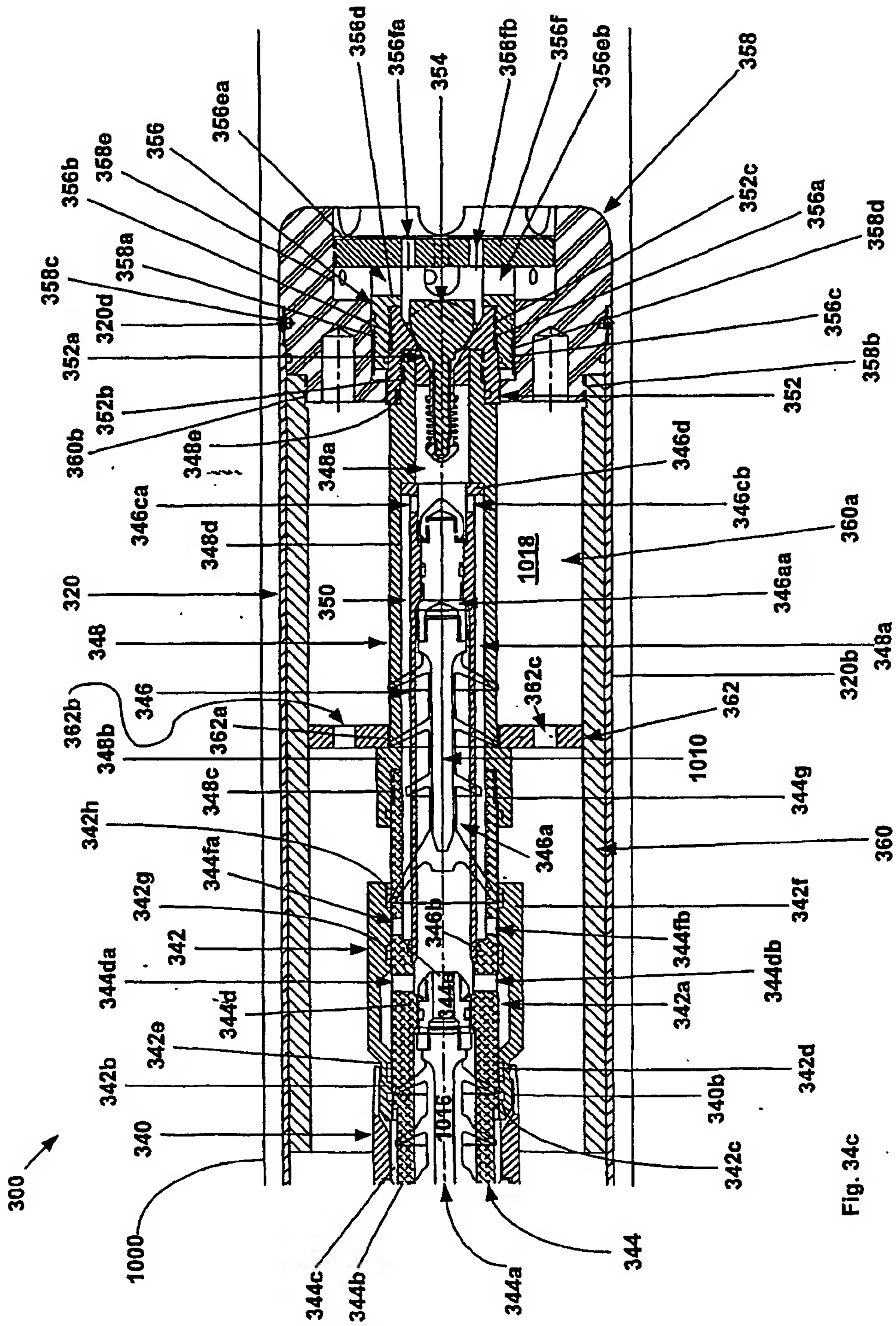
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Fig. 34c

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/28960

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : E21B 23/00, 33/14
US CL : 166/277, 382, 177.4, 206, 207, 242.2
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/277, 382, 177.4, 206, 207, 242.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,718,288 A (BERTET et al) 17 February 1998 (17.02.1998), Figures 3B, 3C and 6-6C.	18, 19, 45 and 46
A	US 3,477,506 A (MALONE) 11 November 1969 (11.11.1969), Figures 1-7.	1-54
X	US 5,337,823 A (NOBILEAU) 16 August 1994 (16.08.1994), Figures 8-12 and column 12, line 56 through column 13, line 6.	18 and 45
A	US 5,667,011 A (GILL et al) 16 September 1997 (16.09.1997), see the entire patent.	1-54
A	US 5,901,789 A (DONNELLY et al) 11 May 1999 (11.05.1999), Figures 1-6.	1-54
A	US 6,012,523 A (CAMPBELL et al) 11 January 2000 (11.01.2000), see the entire patent.	1-54

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
28 November 2001 (28.11.2001)

Date of mailing of the international search report
22 JAN 2002

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703)305-3230

Authorized officer
Hoang Dang Diane Smith for
Telephone No. 703-308-2168

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/28960

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Continuation Sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT	International application No. PCT/US01/28960

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-17, 20-44 and 47-54, drawn to either a method or apparatus for forming a wellbore casing within a borehole within a subterranean formation or a method or apparatus for coupling an expandable tubular member to a preexisting structure.

Group II, claim(s) 18, 19, 45 and 46, drawn to an apparatus for forming a wellbore casing in a borehole in a subterranean or an apparatus for coupling an expandable tubular member to a pre-existing structure.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature for the claims of Group I is the arrangement including valves and fluid passages within the running tool which allows the tubular member to be expanded and cemented. The special technical feature of the claims of Group II is the combination in a single downhole tool of a means for expanding a tubular member and a means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the wellbore.

(12) UK Patent Application (19) GB (11) 2 391 886 (13) A

(43) Date of Printing by UK Office 18.02.2004

(21) Application No: 0323253.5

(22) Date of Filing: 08.11.2001

(30) Priority Data:
(31) 0108638 (32) 06.04.2001 (33) GB

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WO2002/081863 En 17.10.2002

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David M Haugen

(continued on next page)

(51) INT CL[7]:
E21B 43/10, B21D 26/02

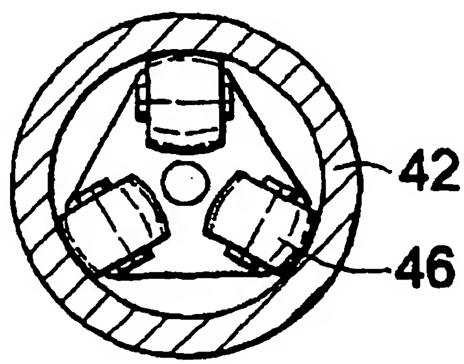
(52) UK CL (Edition W):
E1F FLA
B3J J15

(56) Documents Cited by ISA:
GB 2348223 A
GB 2344606 A
DE 002140358 A
GB 2347950 A
WO 2000/037766 A

(58) Field of Search by ISA:
INT CL[7] B21D, E21B
Other: Online: EPO-Internal, PAJ, WPI Data

(54) Abstract Title: **Downhole apparatus and method for expanding a tubing**

(57) A method of expanding tubing comprises locating an expansion tool in a section of tubing to be expanded, applying a fluid pressure to the tubing to create a fluid pressure expansion force and induce a hoop stress in the tubing, and applying a mechanical expansion force to the tubing via the expansion tool. The combined fluid pressure expansion force and mechanical expansion force is selected to be sufficient to induce expansion of the tubing.



GB 2 391 886 A

This International application has entered the National Phase early

GB 2391886 A continuation

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(51) International Patent Classification[7]: E21B 43/10, B21D 26/02

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(74) Agents: **MCCALLUM, William, Potter** et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).

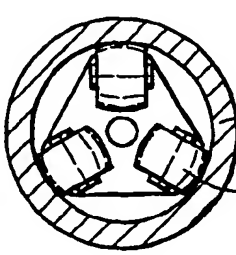
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DOWNHOLE APPARATUS AND METHOD FOR EXPANDING A TUBING



(57) Abstract: A method of expanding tubing comprises locating an expansion tool in a section of tubing to be expanded, applying a fluid pressure to the tubing to create a fluid pressure expansion force and induce a hoop stress in the tubing, and applying a mechanical expansion force to the tubing via the expansion tool. The combined fluid pressure expansion force and mechanical expansion force is selected to be sufficient to induce expansion of the tubing.

WO 02/081863 A1

DOWNHOLE APPARATUS AND METHOD FOR EXPANDING A TUBING

FIELD OF THE INVENTION

This invention relates to tubing expansion, and in particular to expansion of tubing downhole.

BACKGROUND OF THE INVENTION

The oil and gas exploration and production industry is making increasing use of expandable tubing, primarily for use as casing and liner, and also in straddles, and as a support for expandable sand screens. Various forms of expansion tools have been utilised, including expansion dies, cones and mandrels which are pushed or pulled through tubing by mechanical or hydraulic forces. However, these tools require application of significant force to achieve expansion and must be packed with grease to serve as a lubricant between the faces of the cone and the tubing. A number of the difficulties associated with expansion cones and mandrels may be avoided by use of rotary expansion tools, which feature rolling elements for rolling contact with the tubing to be expanded while the tool is rotated and advanced through the tubing; a range of such tools is disclosed in WO00\37766, the disclosure of which is incorporated herein by reference. Although the expansion mechanism utilised in rotary expansion tools tends to require only relatively low actuation forces, the various

parts of the tools may experience high loading, for example the rollers may experience very high point loads where the roller surfaces contact the tubing under expansion. Clearly, such high loadings increase the rate of wear experienced by the tools and the requirement to build the tools with the ability to withstand such loads tends to increase the cost and complexity of the tools.

GB 2348223 A, GB 2347950 A and GB 2344606 A (Shell Internationale Research Maatschappij B.V.) disclose various arrangements in which a tubular member is extruded off a mandrel to expand the member. The axial force necessary to extrude and thus expand the member is achieved by creating an elevated fluid pressure chamber in the tubular member below the mandrel, which pressure creates an axial force on the closed end of the tubular member below the mandrel sufficient to pull the member over the mandrel. The elevated fluid pressure acts only the expanded portion of the tubular member below the mandrel.

US Patent No. 5,083,608 (Abdrakhmanov et al) discloses an arrangement for patching off troublesome zones in a well. The arrangement includes profile pipes which are run into a borehole and then subject to elevated internal pressure to straighten the pipes and bring them into engagement with the surrounding wall of the borehole. A reamer is then rotated within the straightened pipes, with an axial load being applied to the reamer. The reamer is

utilised to expand the threaded joints of the pipe and to further straighten the pipe, and also to provide clearance between a seal on the reamer and the inner wall of the pipe which was utilised to permit the original fluid pressure induced straightening of the pipe.

It is among the objectives of the present invention to provide an expansion method and apparatus which obviates or mitigates one or more disadvantages of the prior art expansion arrangements.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method of plastically expanding a tubing, the method comprising:

applying a fluid pressure expansion force to a section of tubing; and

locating an expansion tool in the pressurised tubing and applying a mechanical expansion force to the pressurised tubing section, the combined fluid pressure force and mechanical expansion force being selected to be sufficient to induce yield of the tubing.

The invention also relates to apparatus for providing such expansion.

The use of a combination of fluid pressure and mechanical forces allows expansion to be achieved using a lower fluid pressure than would be necessary to achieve

expansion when relying solely on fluid pressure to induce expansion, and furthermore provides far greater control of the expansion process; it is generally difficult to predict the form of the expanded tubing that will result from a solely fluid pressure-induced expansion, and failure of tubing in such circumstances is common. Also, the combination of fluid pressure and mechanically-induced expansion allows expansion to be achieved while the loads experienced by the mechanical expansion tool remain relatively low, greatly extending the life of the tools. By way of example, a tubing may be subject to an internal fluid pressure selected to induce a hoop tensile stress which represents 60% of yield. By then applying an additional mechanically-applied expansion force sufficient to induce yield, the tubing may be expanded. Of course the relative proportions of the stress contributed by the fluid pressure and by the expander tool may be varied to suit particular applications, and issues to be taken into account may include: the nature of the tubing to be expanded, as lower quality tubing may respond in an unpredictable manner to elevated hydraulic pressures, such that a greater proportion of the stress must be mechanically applied, and thus greater control exercised over the expansion process; and the capabilities of the apparatus available, for example pump or fluid conduit capabilities may place limits on the applied fluid

pressures.

Various prior art proposals have utilised expansion dies or cones which are urged through tubing under the influence of an axial fluid pressure force acting on the die or cone, or in which tubing is extruded from a mandrel under the influence of axial fluid pressure force acting on the expanded tubing below the mandrel. However, in these instances the fluid pressure force is applied behind or below the die or cone, and the section of the tubing under expansion is not exposed to the elevated die-driving or tubing-extruding fluid pressure. Indeed, in order to provide the force necessary to drive the die or mandrel forward relative to the tubing in such existing arrangements, and to prevent leakage of the driving fluid past the die, it is necessary that there is an effective pressure-tight seal between the die and the expanded tubing. This seal may be provided by the contact between the die and the tubing wall, or by a separate seal assembly provided on the die.

It is a further advantage of the present invention that the fluid being utilised to pressurise the tubing may also serve as a lubricant between the expansion tool and the tubing, facilitating relative movement therebetween and thus reducing the degree of force necessary to move the expansion tool through the tubing. This is of particular significance where the expansion tool is a die or cone, and

the pressurising fluid provides an effectively infinite supply of lubricant, as opposed to the finite supply of grease or other lubricant provided in conventional expansion arrangements (see, for example, GB 2344606 A, in which a body of lubricant 275 is provided in the unexpanded portion of the tubing above the expansion mandrel); once the lubricant has been exhausted, the cone must be retrieved to the surface and repacked. Of course the presence of a lubricant will also reduce the rate of wear to the bearing portions of the expansion tool.

Although intended primarily for use in expanding bore-lining metal tubing, the invention has application in other downhole applications, and may also be used in subsea or surface applications.

The expansion tool may take any appropriate form, including an expansion die or cone, and may be in the form of a cone or other member carrying a plurality of rollers rotatable about axes substantially perpendicular to the tubing axis. However, it is preferred that the expansion tool is a rotary expansion tool, or rolling element expander, that is the tool features at least one expansion member which, in use, is in rolling contact with the tubing wall; the expansion member may follow a circumferential or helical contact path with the tubing wall. Most preferably, the expansion members are conical in form or are mounted on axes arranged to define a cone. In another

embodiment of the invention, a rotating expansion tool may be utilised which features a non-rotating expansion member or members, preferably of a relatively hard material such as a ceramic material, which provides a sliding contact with the tubing wall. The members may be radially extendable or may be radially fixed. In one embodiment, blocks of silicon carbide or titanium carbide may form the expansion members.

Preferably, the expansion tool is fluid pressure actuated, and may include a hydraulic drive motor to rotate the tool; the motor may utilise the fluid providing the expansion force as a drive fluid, the fluid exhausting into a lower pressure section of the bore isolated from the expansion section. In other embodiments, an electric motor may be utilised.

The expansion tool is preferably provided in combination with a seal assembly, for providing a fluid-tight seal with the unexpanded tubing ahead of the expansion tool. As the fluid pressure in the unexpanded tubing ahead of the seal assembly will tend to be lower than the elevated pressure behind the seal assembly, this differential pressure will tend to produce an axial pressure force acting on the seal assembly, which may be utilised to drive the expansion tool forwards.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic sectional view of tubing expansion apparatus in accordance with a preferred embodiment of the present invention;

Figure 2 is a diagrammatic part-sectional view of an expansion tool of expansion apparatus in accordance with another embodiment of the present invention;

Figures 3, 4, 5 and 6 are sectional views on lines 3 - 3, 4 - 4, 5 - 5 and 6 - 6 of Figure 2; and

Figure 7 is a diagrammatic part-sectional view of an expansion apparatus in accordance with a further embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is first made to Figure 1 of the drawings, which illustrates expansion apparatus 10 in accordance with a preferred embodiment of the present invention, shown located in the upper end of a section of tubing in the form of bore liner of expandable metal, hereinafter referred to as liner 12. In use, the apparatus 10 and liner 12 are run into a drilled bore together, and the liner 12 positioned in a section of unlined bore, and possibly overlapping the lower end of existing bore-lining casing. The apparatus 10

is then operated to expand the liner 12 to a larger diameter, the liner of the original, unexpanded diameter being identified as liner 12a, and the expanded larger diameter liner being identified by the reference numeral 12b.

The apparatus 10 includes a rolling element expander 14 having a generally conical body 16 carrying a number of rolling elements 18. The expander 14 is coupled to a hydraulic drive motor 20 mounted on a running tube 22 which extends upwardly, through a stuffing box 24, to surface. The stuffing box 24 is provided in an upper seal assembly 26 mounted to the top of the liner 12. Mounted below the expander 14, via a swivel 28, is a lower seal assembly 30 which is adapted to provide a sliding seal with the unexpanded liner 12a.

In use, the volume 32 defined by the liner 12 between the seal assemblies 26, 30 is supplied with high pressure hydraulic fluid from an appropriate source, such as a surface or downhole pump. In Figure 1 a hydraulic fluid inlet 34 is illustrated as passing radially through a part of the upper seal assembly 26, however in practice the inlet 34 would be arranged axially, to allow accommodation of the apparatus 10 in a bore, and to allow supply of hydraulic fluid via a running tube in the form of a coaxial coil tubing or drill pipe. The pressure of the hydraulic fluid is selected to induce a predetermined hoop tensile

stress within the liner 12. The hydraulic fluid exhausts through the drive motor 20, which includes a hydraulic fluid driven turbine, the exhausted fluid passing up to the surface via the running tube 22.

The exhausted fluid is throttled, or the flow and pressure of the fluid otherwise controlled, to control the pressure within the volume 32, and also the operation of the motor. The throttling may take place downhole or at surface.

The passage of fluid through the motor 20 causes the motor to rotate the expander 14, and thus if the motor 20 is advanced through the liner 12, the expander 14 will act on the transition portion 12c between the section of unexpanded and expanded liner 12a, 12b. The forces acting on the transition portion 12c comprise a combination of the stress induced by the elevated hydraulic fluid pressure within the volume 32, and the mechanical pressure forces applied by the surfaces of the rolling elements 18. The combination of forces is selected so as to be sufficient to induce yield and thus plastic deformation of the liner 12.

As noted above, the lower seal assembly 30 isolates the pressurised volume 32 from the remainder of the unexpanded liner 12a, which is at a lower pressure than the volume 32. Accordingly, the differential pressure acting on the assembly 30 produces an axial force tending to push the apparatus 10 through the liner 12. There is thus no

requirement to apply weight from surface to the apparatus 10.

EXAMPLE

A liner 12 to be expanded is 7⅝" 29.7 lb\ft N80 tubing which has a burst pressure of approximately 7,000 psi. The hydraulic fluid supplied to the volume 32 is at 5,000 psi. The liner wall is therefore subjected to a tensile stress of 51,000 psi, which represents 63% of the yield for the liner (not taking into account the effect of radial stress in the region of 25,000 psi).

The drive fluid to the hydraulic motor 20 enters through an inlet port 36 and exhausts into the running tube 22, thereby adding the motor pressure drop to the applied internal pressure. The hydraulic return to surface is throttled to maintain the applied liner pressure, taking into account the motor pressure drop and the parasitic losses in the running tube 22.

The net axial force applied to the expansion assembly is the pressure differential across the lower seal assembly 30 times its cross-sectional area minus the pressure differential across the stuffing box 24 times the cross-sectional area of the running tube 22. If the running tube 22 has an outside diameter of 5" and the internal diameter of the 7⅝" liner is 6.88", then the down force applied to the assembly is 83,000 lbf, which is in excess of the force

required to drive the expander 14 through the liner 12, such that a braking assembly must be provided on surface for the running tube 22. Alternatively, a larger diameter running tube 22 could be utilised.

Reference is now made to Figures 2 to 6 of the drawings, which illustrate an alternative expander 40 in accordance with a further embodiment of the present invention, shown located in a section of liner 42 during expansion. From a comparison of the figures, those of skill in the art will recognise that Figure 2 shows various internal features of the expander 40.

The expander 40 features a generally conical body 44 on which are mounted five rows of rollers 46, 47, 48, 49 and 50 (the section shown in Figure 6 corresponds to both sections 6-6 and 6a-6a of Figure 2). Unlike the rolling elements 18 of the first described embodiment, the rollers 46 to 50 rotate around axes that lie substantially perpendicular to the liner axis, and the expander 40 is therefore intended to advance axially through the liner 42, without rotation.

Such an expander configuration would not be practical in the absence of assisting hydraulic expansion forces, as the bearing loads experienced on expanding heavy walled tubing would far exceed the capabilities of the bearings that could be installed in the limited space available. However, with applied internal hydraulic pressure providing

the bulk of the expansion forces, the roller bearings are relatively lightly loaded.

Reference is now made to Figure 7 of the drawings, which illustrates an expansion apparatus 60 in accordance with a further embodiment of the present invention located within a partially expanded borehole liner 58.

The apparatus 60 includes an expander cone 62 mounted to a tubular running string 64, and mounted below the cone 62 is a seal assembly 66 adapted to provide a sliding seal with the unexpanded liner 58.

As with the above described embodiments, an elevated fluid pressure above the seal assembly 66 provides an initial expansion force acting on the liner 58, while the passage of the cone 62 provides a further mechanical expansion force which, in combination with the hydraulic expansion force, is sufficient to induce yield in the liner 58. The axial pressure force acting on the seal assembly 66 may also serve to drive the cone 60 through the tubing 58, and the presence of the pressurising force around the cone 62 provides an effectively infinite supply of lubricant for the cone 62; fluid communication across the cone 62 may be assured by providing linked ports 68, 70 above and below the cone 62.

It will be apparent to those of skill in the art that the above-described embodiments provide an alternative method for expanding tubing downhole, and that the

invention offers a number of advantages over existing systems.

Furthermore, those of skilled in the art will recognise that the above-described embodiments are merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the invention. For example, in the embodiment of Figure 1, rather than providing a hydraulic fluid driven motor 20 within the pressurised volume 32, a motor may be provided externally of the volume 32, and may be located downhole or at surface. In this case, the upper seal assembly 26 would of course have to be modified to accommodate rotation.

CLAIMS

1. A method of expanding tubing, the method comprising:

locating an expansion tool in a section of tubing to be expanded;

applying fluid pressure to said section of tubing to create a fluid pressure expansion force and induce a hoop stress in said section of tubing; and

applying a mechanical expansion force to said tubing section via said expansion tool, the combined fluid pressure expansion force and mechanical expansion force being selected to be sufficient to induce expansion of the tubing.

2. The method of claim 1, further comprising locating the tubing downhole.

3. The method of claim 1 or 2, comprising inducing plastic deformation of the tubing.

4. The method of claim 1, 2 or 3, comprising selecting the fluid pressure to create a hoop stress in said tubing section representing at least 25% of the yield stress of the tubing.

5. The method of claim 4, comprising selecting the fluid pressure to create a hoop stress in said tubing section representing at least 40% of the yield stress of the tubing.

6. The method of claim 5, comprising selecting the fluid pressure to create a hoop stress in said tubing section representing at least 50% of the yield stress of the tubing.

7. The method of claim 6, comprising selecting the fluid pressure to create a hoop stress in said tubing section representing at least 60% of the yield stress of the tubing.

8. The method of any of the preceding claims, further comprising utilising fluid utilised to create the fluid pressure expansion force as a lubricant between the expansion tool and the tubing.

9. The method of any of the preceding claims, comprising providing the expansion tool is the form of an expansion die and running the die axially through the tubing section.

10. The method of any of claims 1 to 8, comprising providing the expansion tool in the form of an expansion

member carrying a plurality of rolling expansion members rotatable about axes which are substantially perpendicular to the tubing axis, and running the expansion member axially through the tubing section.

11. The method of any of claims 1 to 8, comprising providing the expansion tool in the form of a rolling element expander having at least one expansion member in rolling contact with the tubing wall, and rotating the expander in the tubing section.

12. The method of any of the preceding claims, comprising utilising fluid to actuate the expansion tool.

13. The method of claim 12, comprising providing a hydraulic drive motor to rotate the expansion tool, the motor utilising fluid providing the fluid pressure expansion force as a drive fluid.

14. The method of any of the preceding claims, comprising providing the expansion tool in combination with a seal assembly providing a fluid-tight seal with the unexpanded tubing ahead of the expansion tool.

15. The method of claim 14, comprising applying said fluid pressure to the seal assembly to drive the expansion tool

axially relative to the tubing.

16. A method of expanding a tubular, comprising:

(a) applying fluid pressure to an inside surface of the tubular;

(b) applying a mechanical force to the inside surface of the tubular; and

(c) expanding the tubular with the combination of the fluid pressure and the mechanical force.

17. A method of increasing an outer diameter and inner diameter of a tubular, comprising:

(a) applying fluid pressure to an inside surface of the tubular;

(b) applying a mechanical force to the inside surface of the tubular; and

(c) increasing the outer diameter and the inner diameter of the tubular with the combination of the fluid pressure and the mechanical force.

18. A method of increasing an outer diameter and inner diameter of a tubular, comprising:

(a) applying fluid pressure to an inside surface of the tubular;

(b) applying a mechanical force to the inside surface of the tubular at least partially simultaneously with the

application of fluid pressure; and

(c) increasing the outer diameter and the inner diameter of the tubular with the combination of the fluid pressure and the mechanical force.

19. The method of claim 16, 17 or 18, wherein the tubular is a downhole tubular.

20. The method of claim 16, 17, 18 or 19, wherein the fluid pressure causes the tubular wall to approach its yield strength.

21. The method of any of claims 16 to 20, wherein the mechanical force urges the tubular to expand.

22. The method of any of claims 16 to 21, wherein the expansion is plastic.

23. A method of plastically expanding a downhole tubular, comprising applying a combination of hydraulic and mechanical expansion forces to unexpanded and expanding portions of the tubular wall, the applied hydraulic expansion force being selected to provide sufficient stress in the tubular wall to cause the wall to approach but not exceed its yield strength, and the mechanically applied force providing an additional stress required to push the

tubular wall through yield and causing controlled local expansion of the tubular wall.

24. Apparatus for expanding a tubing, the apparatus comprising:

means for isolating the interior of a section of tubing;

means for supplying fluid at elevated pressure to the isolated section of tubing to create a fluid pressure expansion force on the tubing wall; and

an expansion tool for location in the pressurised section of tubing and adapted to apply a mechanical expansion force to the tubing wall simultaneously with the fluid pressure expansion force.

25. The apparatus of claim 24, wherein the expansion tool is an expansion die adapted to be moved axially through the tubing section.

26. The apparatus of claim 24, wherein the expansion tool has a body carrying a plurality of expansion members rotatable about axes substantially perpendicular to the tubing axis and is adapted to be moved axially through the tubing section.

27. The apparatus of claim 24, wherein the expansion tool

has at least one expansion member and is adapted to be rotated in the tubing section.

28. The apparatus of claim 27, wherein the expansion member is radially movable.

29. The apparatus of claim 27 or 28, wherein the expansion tool is a rolling element expander having a plurality of rotatable expansion members.

30. The apparatus of claim 29, wherein the expansion members are arranged to define a cone.

31. The apparatus of any of claims 24 to 30, wherein the expansion tool is fluid pressure actuated.

32. The apparatus of claim 31, wherein the expansion tool includes a hydraulic drive motor to rotate parts of the tool.

33. The apparatus of any of claims 24 to 32, wherein said isolating means includes a seal assembly for providing a fluid-tight seal with unexpanded tubing ahead of the expansion tool.

34. The apparatus of claim 33, wherein a swivel is

provided between the expansion tool and the seal assembly.

35. The apparatus of any of claims 23 to 34, wherein said means for supplying fluid at elevated pressure includes a first conduit for carrying fluid to the interior of the section of tubing and a second conduit for carrying fluid from said section of tubing.

36. The apparatus of any of claims 24 to 35, wherein said means for supplying fluid at elevated pressure includes a coaxial support member.

37. The apparatus of any of claims 24 to 36, wherein said means for supplying fluid at elevated pressure includes a throttle for controlling the pressure of fluid in said section of tubing.

38. The apparatus of any of claims 24 to 37, in combination with a section of expandable tubing.

39. The combination of claim 38, wherein the tubing is bore-lining tubing.

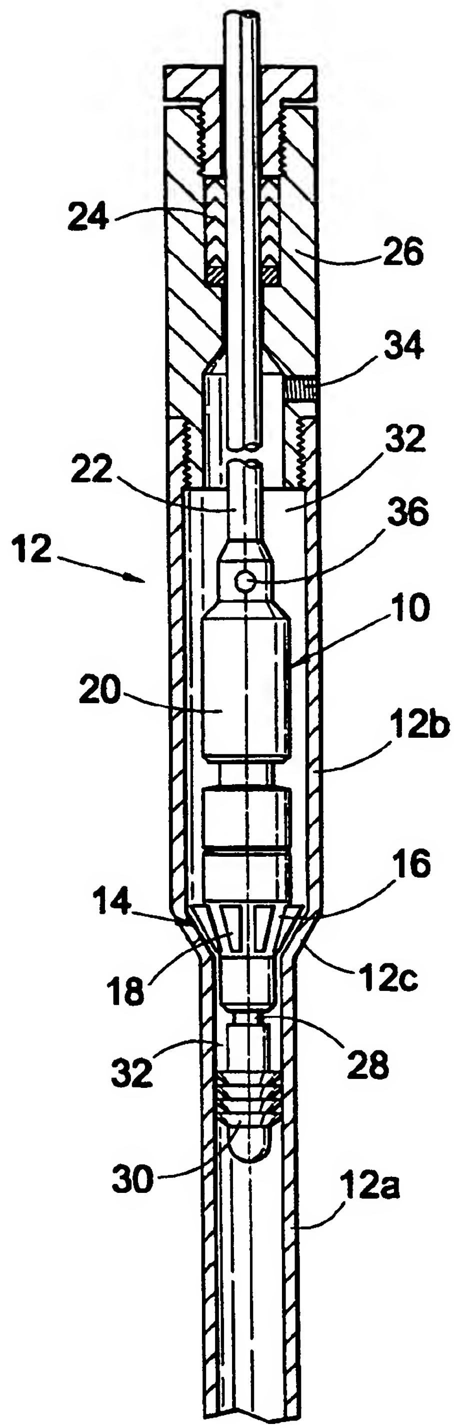


Fig.1

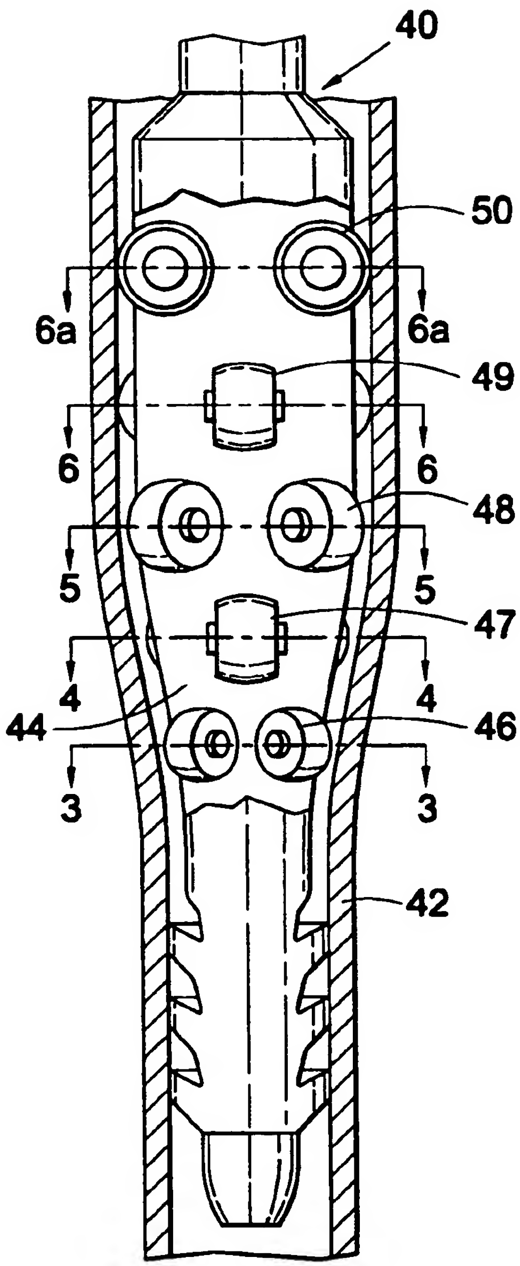


Fig.2

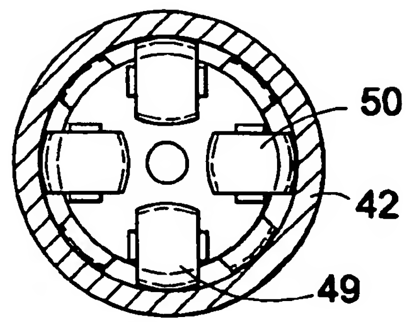


Fig.6

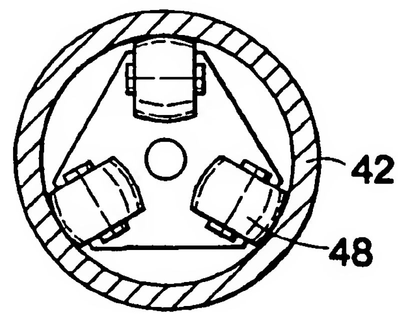


Fig.5

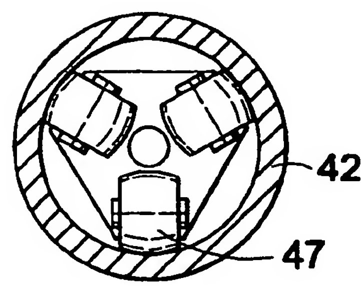


Fig.4

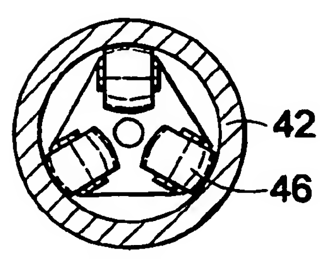


Fig.3

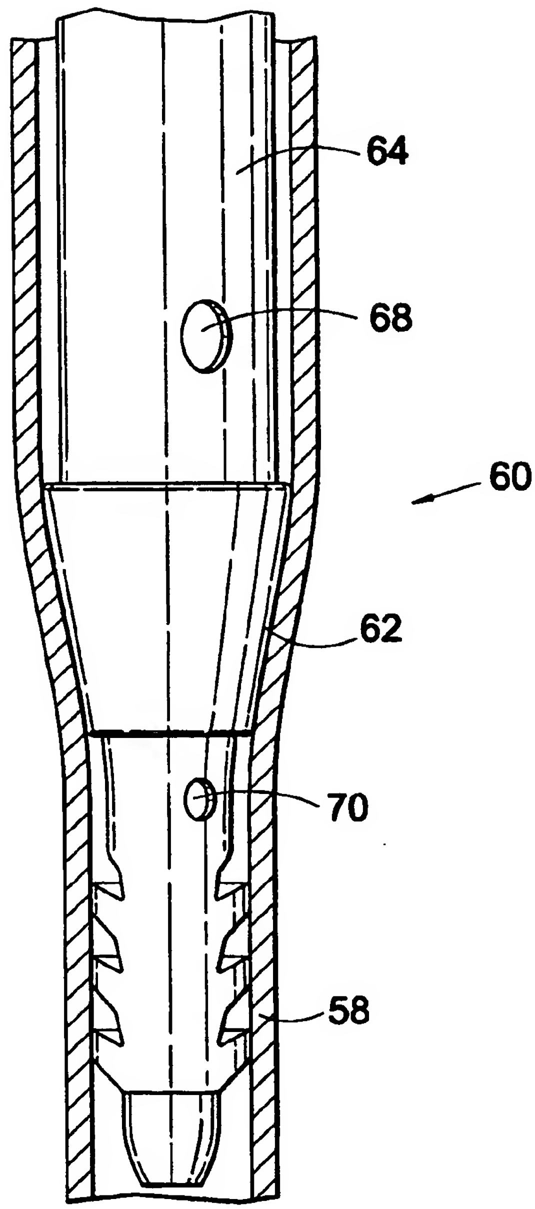


Fig.7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/04958

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/10 B21D26/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 January 2002	30/01/2002

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/04958

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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